CONNECTICUT RIVER BASIN
HAVERHILL, NEW HAMPSHIRE

OLSEN DAM

NH 00190

NHWRB 112.09

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is 660 ft. long and 30.5 ft. high. It is small in size with a high hazard potential. The dam is in fair condition at the present time.Further investigation of the downstream slope and the outlet conduit is recommended when, and if, the downstream reservoir is lowered so as to expose these elements.

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	NH 00190
NHWRB No.:	112.09
Name of Dam:	Olsen Dam
Town:	Haverhill
County and State:	Grafton County, New Hampshire
Stream:	Waterman Brook, a tributary of the Wild Ammonoosuc River which is a tributary the Connecticut River
Date of Inspection:	June 5, 1980

BRIEF ASSESSMENT

The Olsen Dam (also known as Upper Mountain Lake Dam) is located on Waterman Brook, approximately three quarters of a mile upstream of its confluence with the Wild Ammonoosuc River in Haverhill, New Hampshire. The dam is 660 feet long and 30.5 feet high. It consists of an earth embankment with a concrete drop inlet type principal spillway and a grass lined earth channel emergency spillway at the right abutment. The reservoir from Lower Mountain Lake Dam, immediately downstream, submerges most of the downstream slope of the dam.

The dam is owned by the Town of Haverhill, New Hampshire. It was designed and constructed to serve as a recreation area. At present, it also serves as a water supply reservoir for approximately 200 homes.

The drainage area of the dam covers 3.4 square miles and is made up primarily of rolling woodland with some minor development and pasture. The dam has a maximum impoundment of 499 acre feet. The dam is SMALL in size and its hazard classification is HIGH since significant economic loss and the potential for loss of more than a few lives could result in the event of a dam failure.

Because of its small size and high hazard classification, the test flood for this dam could range from one-half of the Probable Maximum Flood (PMF) to the Probable Maximum Flood. Because the risk downstream is on the low side of the high hazard classification, a test flood of 3,935 (approximately one half of the PMF) has been adopted as the test flood for this dam. Because of storage, the resulting peak discharge would be 3470 cfs compared to a total spillway capacity of 1,640 cfs. The water surface would be at elevation 782.4 feet (msl) or 0.8 feet above the top of the dam for this flood. The combined spillways are capable of passing 47 percent of the adopted test flood outflow for this dam.

The dam is in FAIR condition at the present time. It is recommended that the owner retain a qualified registered professional engineer for further hydraulic/hydrologic studies to determine overtopping potential. Further investigation of the downstream slope and the outlet conduit is recommended when, and if, the downstream reservoir is lowered so as to expose these elements. Remedial measures to be undertaken by the owner include: implementing annual maintenance and inspection programs, regrading the slopes and placing rip rap or other form of slope protection, providing a workable means of lowering the reservoir in the event of an emergency, curtailing the future placement of equipment or material in the emergency spillway channel, and developing a formal written system for warning downstream officials in the event of an emergency.

The recommendations and remedial measures outlined above should be implemented within one year of receipt of this report by the owner.

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

TABLE OF CONTENTS

Section	Page
Letter of Transmittal	
Brief Assessment	
Review Board Page	
Preface	i
Table of Contents	ii
Overview Photo	v
Location Map	vi
REPORT	
1. PROJECT INFORMATION	1-1
1.1 General	1-1
a. Authority	1-1
b. Purpose of Inspection	1-1
1.2 Description of Project	1-1
a. Location	1-1
b. Description of Dam and Appurtenances	1-2
c. Size Classification	1-3
d. Hazard Classification	1-3
e. Ownership	1-3
f. Operator	1-3
g. Purpose of Dam	1-3
h. Design and Construction History	1-3
i. Normal Operational Procedure	1-3
1.3 Pertinent Data	1-4
2. ENGINEERING DATA	2-1
2.1 Design Data	2-1
2.2 Construction Data	2-1

TABLE OF CONTENTS - (cont.)

Section	Page
2.3 Operation Data	2-1
2.4 Evaluation of Data	2-1
3. VISUAL INSPECTION	3-1
3.1 Findings	3-1
a. General	3-1
b. Dam	3-1
c. Appurtenant Structures	3-1
d. Reservoir Area	3-2
e. Downstream Channel	3-2
3.2 Evaluation	3-2
4. OPERATIONAL AND MAINTENANCE PROCEDURES	4-1
4.1 Operational Procedures	4-1
a. General	4-1
b. Description of any Warning System in Effect	4-1
4.2 Maintenance Procedures	4-1
a. General	4-1
b. Operating Facilities	4-1
4.3 Evaluation	4-1
5. EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES	5-1
5.1 General	5-1
5.2 Design Data	5-1
5.3 Experience Data	5-1
5.4 Test Flood Analysis	5-1
5.5 Dam Failure Analysis	5-2

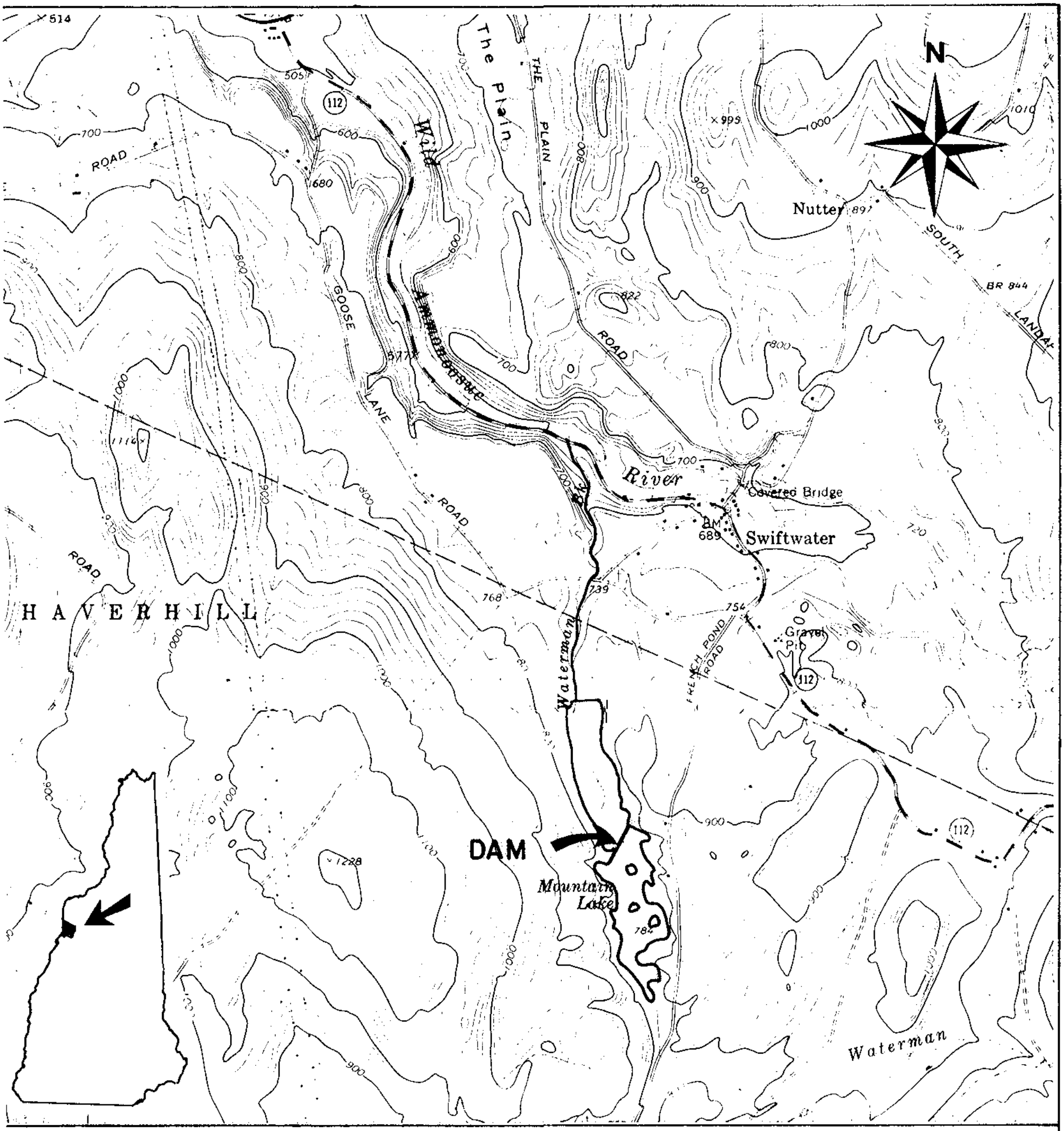
TABLE OF CONTENTS - (cont.)

Section		Page
6.	EVALUATION OF STRUCTURAL STABILITY	6-1
	6.1 Visual Observation	6-1
	6.2 Design and Construction Data	6-1
	6.3 Post-Construction Changes	6-1
	6.4 Seismic Stability	6-1
7.	ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES	7-1
	7.1 Dam Assessment	7-1
	a. Condition	7-1
	b. Adequacy of Information	7-1
	c. Urgency	7-1
	7.2 Recommendations	7-1
	7.3 Remedial Measures	7-1
	7.4 Alternatives	7-2

APPENDICES

APPENDIX A	INSPECTION CHECKLIST	A-1
APPENDIX B	ENGINEERING DATA	B-1
APPENDIX C	PHOTOGRAPHS	C-1
APPENDIX D	HYDROLOGIC AND HYDRAULIC COMPUTATIONS	D-1
APPENDIX E	INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS	E-1

Overview of Dam



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FROM: USGS LISBON - N.H. & EAST HAVERHILL - N.H. QUADRANGLE MAP.

GOLDBERG-ZOINO & ASSOCIATES, INC. GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS NEWTON UPPER FALLS, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION PLAN

OLSEN DAM — HAVERHILL, NEW HAMPSHIRE

SCALE AS SHOWN

DATE

FILE No. 2605

National Dam Inspection Program

Phase I Inspection Report

Olsen Dam

Section I: Project Information

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg-Zoino & Associates, Inc. (GZA) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to GZA under a letter of April 17, 1980 from Colonel William E. Hodgson, Jr., Corps of Engineers. Contract No. DACW 33-80-C-0055 has been assigned by the Corps of Engineers for this work.

(b) Purpose

1) Perform technical inspections and evaluations of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

3) Update, verify, and complete the National Inventory of Dams.

1.2 Description of Dam

(a) Location

The Olsen Dam (also known as Upper Mountain Lake Dam) is located in the Connecticut River Basin on Waterman Brook approximately three quarters of a mile upstream of its confluence with the Wild Ammonoosuc River in Haverhill, New Hampshire. It can be reached from French Pond Road which intersects State Route 112 in Haverhill, New Hampshire. The dam is shown on U.S.G.S. East Haverhill-New Hampshire Quadrangle at approximate coordinates N4407.3, W7157.5 (see location map on page vi). Page B-2 of Appendix B is a Site Plan for this dam.

(b) Description of Dam and Appurtenances

The dam consists of an earth embankment with an earth fill cutoff trench below the embankment, a principal spillway with a reinforced concrete riser and corrugated metal outlet pipe, and an emergency spillway located at the right abutment. The total length of the dam is 660 feet of which 90 feet is the emergency spillway.

1) Embankment (See page B-3)

The embankment is made up primarily of silty sand and gravel. It is 570 feet long and a maximum of 30.5 feet high. As measured during the inspection the crest width is 15 feet and the side slopes are 2 horizontal to 1 vertical. The design drawings show side slopes of 3 horizontal to 1 vertical and a crest width of 6 feet. The elevations shown on B-3 are referenced to an unknown datum. The dam crest is at elevation 781.6 (MSL).

According to available plans there is an earthfill cutoff trench which is 8 feet wide and approximately 2 feet deep and backfilled with impervious material. This forms the bottom of an impervious core which extends vertically to within three feet of the crest of the dam.

2) Principal Spillway (see page B-3)

The principal spillway consists of a precast concrete drop inlet manhole structure with an 18 inch pond drain inlet pipe and an uncontrolled orifice inlet. The outlet pipe is a 42 inch diameter corrugated metal pipe with bituminous coating and it is approximately 99 feet long. The pond drain pipe is plugged and therefore is inoperable.

The riser structure is 18.5 feet high and 5 feet in diameter. At the bottom of the structure is a 18 inch diameter pond drain inlet pipe which extends 46 feet into the reservoir. The pond drain invert is at elevation 758.6 feet (msl).

The 5 foot diameter drop inlet opening is at elevation 775.6. It is 6.0 feet below the crest of the dam. There are two wire mesh screens which act as trash racks at the principal spillway inlet. The first surrounds the inlet itself and the second surrounds the timber platform which covers the inlet.

3) Emergency Spillway (see page B-3 & B-5)

The emergency spillway was excavated in the left abutment. It is 90 feet wide at the control section and it curves to the right around the embankment. It is approximately 200 feet long and lies approximately 3.3 feet below the crest of the dam. The side slopes are 3 horizontal to 1 vertical. The control section is at elevation 778.3 feet (msl).

(c) Size Classification

The dam's maximum impoundment of 499 acre feet and height of 30.5 feet place it in the SMALL size category according to the Corps of Engineer's Recommended Guidelines.

(d) Hazard Potential Classification

The hazard potential classification for this dam is HIGH because of the significant economic loss and the potential for loss of more than a few lives which could occur in the event of a dam failure. Section 5 of this report presents a more detailed discussion of the hazard potential.

(e) Ownership

The dam was originally owned by Mr. Louigi Castello, Mr. Karl Bruckner, and Mr. Morris Olsen of Haverhill New Hampshire. It is now owned by the Town of Haverhill, New Hampshire. The owner's representative, Mr. Robert Messini, can be reached by telephone at (603) 747-3622.

(f) Operator

The operation of the dam is controlled by the Owner. Mr. Robert Messini, the caretaker, can be reached by telephone at (603) 747-3622.

(g) Purpose of the Dam

The dam was constructed as a recreation area. It now also provides storage for the water supply reservoir downstream.

(h) Design and Construction History

The dam was designed by Mr. William F. Callahan of Bath, New Hampshire. Construction was accomplished by the Moulton Construction Company of Lebanon, New Hampshire. The dam was completed in 1963.

(i) Normal Operating Procedure

The dam is normally self regulating.

1.3 Pertinent Data

(a) Drainage Area

The drainage area for this dam covers 3.4 square miles. It is made of primarily of mountainous woodland with some pasture and minor development.

(b) Discharge at Dam Site

1) Outlet Works

There are no outlet works at this dam.

2) Maximum Known Flood

No records of flow or stage are available for this dam.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the principal spillway with the reservoir at top of dam elevation (781.6 feet msl) is 120 cfs. The capacity of the emergency spillway is 1520 cfs at this level.

4) Ungated Spillway Capacity at Test Flood

The capacity of the principal spillway with the reservoir at test flood elevation (782.4 feet msl) is 120 cfs. The capacity of the emergency spillway is 2130 cfs at this level.

5) Gated Spillway Capacity at Normal Pool

There are no gated spillways.

6) Gated Spillway Capacity at Test Flood

There are no gated spillways.

7) Total Spillway Capacity at Test Flood

The total spillway capacity at test flood elevation (782.4 feet msl) is 2,250 cfs.

8) Total Project Discharge at Top of Dam

The total project discharge at top of dam elevation (781.6 feet msl) is 1640 cfs.

9) Total Project Discharge at Test Flood Elevation

The total project discharge at test flood elevation (782.4 feet msl) is 3470 cfs.

(c) Elevation (feet above msl)

1) Streambed at toe of dam: approximately 757.1

2) Bottom of cutoff: Unknown

3) Maximum tailwater: Unknown, Downstream normal pool 774.0
Downstream top of dam 778.0

4) Recreation Pool: Approximately 775.6

5) Full flood control pool: Not applicable

6) Spillway crest:

Principal Spillway: 775.6
Emergency Spillway: 778.3

7) Design surcharge: 781.6

8) Top of dam: 781.6

9) Test flood surcharge: 782.4

(d) Reservoir (length in feet)

1) Normal pool: 2500

2) Flood control pool: Not applicable

3) Spillway crest pool: 2500

4) Top of dam pool: 2500

5) Test flood pool: 2500

(e) Storage (acre-feet)

1) Normal pool: 325

2) Flood control pool: Not applicable

3) Emergency spillway crest pool: 397

4) Top of dam pool: 499

5) Test flood pool: 528

(f) Reservoir Surface (acres)

1) Normal pool: approximately 24

2) Flood control pool: Not applicable

3) Emergency spillway crest: approximately 28.5

4) Test flood pool: approximately 35.2

5) Top of dam: approximately 33.9

(g) Dam

1) Type: Earth embankment with concrete spillway

2) Length: Approximately 660 feet

3) Height: Approximately 30.5 feet

4) Top width: Approximately 15 feet

5) Side slopes: Approximately 2 horizontal to 1 vertical

6) Zoning: Silty sand and gravel shells with central core of "impervious fill"

7) Impervious core: Variable width to 3 feet below crest

8) Cutoff: Impervious earth trench, 8 feet wide, 2 feet deep

9) Grout curtain: Unknown

(h) Diversion and Regulating Tunnel

Not applicable

(i) - Spillways

1) Type:

Principal Spillway: Precast concrete manhole drop inlet

Emergency Spillway: Grass lined earth channel cut in the right abutment

2) Length of weir:
Principal Spillway: 15.7 foot circumference
Emergency Spillway: 90 feet

3) Crest elevation:
Principal Spillway: 775.6 feet (msl)
Emergency Spillway: 778.3 feet (msl)

4) Gates: None

5) Upstream channel: Reservoir

6) Downstream channel: Reservoir

(j) Regulating Outlets

There are no regulating outlets on this dam. The pond drain consists of an 18 inch diameter pipe with its invert at elevation 758.6 feet (msl). This outlet is plugged and inoperable.

Section 2: Engineering Data

2.1 Design Data

The only design data available for this dam are three design drawings by Mr. William F. Callahan of Bath, New Hampshire. Significantly lacking are data on the foundation conditions and embankment drainage features.

2.2 Construction Records

No construction records are available for this dam.

2.3 Operational Records

No operational records are available for this dam.

2.4 Evaluation of Data

(a) Availability

The lack of detailed design and construction data warrants an unsatisfactory assessment for availability.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment of the dam is based primarily on the visual inspection, past performance and sound engineering judgement.

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the records of the New Hampshire Water Resources Board, a satisfactory evaluation for validity is indicated.

Section 3: Visual Inspection

3.1 Findings

(a) General

The Olsen Dam is in GOOD condition at the present time.

(b) Dam

1) Main Dam Embankment (see photos 1,2,3,5,6,7)

The embankment appears to be in good condition at the present time. The upstream slope at the waterline shows some signs of erosion and undercutting due to wave action. A few small shrubs are growing on the upstream slope at the water line. At approximately midlength along the downstream slope are a few small (2 inch) animal burrows approximately four feet below the crest of the dam. There are utility poles embedded in the embankment and a compacted gravel roadway running along the crest to a club house at the left end of the embankment.

Immediately downstream of the dam is the reservoir impounded by the Lower Mountain Lake Dam. Only the top 8 to 10 feet of the embankment was inspected. The lower portion of the downstream slope is submerged below the surface and this portion of the embankment could not be inspected.

2) Emergency Spillway (see photos 6 & 7)

The emergency spillway is located at the left abutment. There is a play area and beach including recreation equipment located on the emergency spillway which is a grasslined channel. The channel appears to be in good condition with the exception of the equipment which would restrict flow.

roadway ?

(c) Appurtenant Structures (see Photo's 3 & 4)

The drop inlet type spillway consists of a five foot diameter riser pipe leading to a 42 inch diameter outlet conduit which passes under the embankment. There is a pond drain of 18 inch diameter pipe extending into the upstream reservoir.

The drop inlet riser is enclosed with a wooden deck and protected by two wire screen trash racks around the inlet and the deck. The deck and trash rack appear to be in good condition. There is some debris caught in the trash racks.

The pond drain and outlet conduit were completely submerged and could not be inspected.

(d) Reservoir Area (see photo 7)

The shore of the reservoir is generally shallow sloping woodland. It appears stable and in good condition.

(e) Downstream Channel (see photo 1 and overview)

The downstream channel is the reservoir of Lower Mountain Lake. The shores of this reservoir are generally shallow sloping woodland and appear stable and in good condition.

3.2 Evaluation

The dam is generally in good condition. The potential problems noted during the visual inspection are listed below:

(a) Animal burrows in downstream slope of the embankment.

(b) Debris in trash racks.

(c) Lack of slope protection.

(d) Placement of recreational equipment and roadway embankment in the emergency spillway channel. ?

Section 4: Operational and Maintenance Procedures

4.1 Operational Procedures

(a) General

No written operational procedures exist for this dam.

(b) Description of any Warning System in Effect

There is no warning system in effect.

4.2 Maintenance Procedures

(a) General

No formal maintenance program exists for the dam. Maintenance appears to be accomplished on an as-needed basis.

(b) Operating Facilities

No formal maintenance program exists and maintenance is performed infrequently.

4.3 Evaluation

Additional emphasis on routine maintenance will assist the owner in assuring the long-term safety of the dam and operating facilities. A formal, written, downstream emergency warning system should be developed for this dam.

Section 5: Evaluation of Hydraulic/Hydrologic Features

5.1 General

Olsen Dam is an earth embankment located on Waterman Brook approximately 2,500 feet upstream of Lower Mountain Lake Dam. The reservoir upstream of Olsen Dam has a surface area of approximately 27 acres and has a maximum impoundment of 487 acre-feet.

The reservoir of Lower Mountain Lake Dam is directly downstream of Olsen Dam. Lower Mountain Lake Dam was the subject of a separate Dam Safety Report dated March, 1979. According to this report, the normal pool of Lower Mountain Lake is at elevation 774.0 feet (MSL) which is 1.6 feet lower than Upper Mountain Lake as determined by field measurement.

Immediately downstream of Lower Mountain Lake Dam is a pump station for a public water supply system. The station draws water from Waterman Brook and is about 9 feet above the channel bottom. In the next 1,500 feet downstream of Lower Mountain Lake Dam the only development is Goose Pond Road which crosses Waterman Brook on an earth embankment with an 8 foot by 6 foot corrugated metal arch culvert.

The next development of Waterman Brook is a house about 5 feet above the stream channel and 3,300 feet downstream of Lower Mountain Lake Dam (5,800 feet downstream of Olsen Dam). Near this house is the upstream end of a normally dry draw with its invert about 5 feet above the stream channel. Flow from Waterman Brook would enter this draw when the stage is high enough. About 200 feet down the draw there is a house within 2 feet of the draw bottom.

About 6,000 feet downstream of Olsen Dam, both the draw and Waterman Brook cross New Hampshire Highway 112 before entering the Wild Ammonoosuc River. The highway crosses Waterman Brook on a 10 foot wide by 5 foot high bridge. Less than 100 feet downstream of New Hampshire Highway 112, Waterman Brook enters the Wild Ammonoosuc River.

5.2 Design Data

Data sources available for Olsen Dam include plans for the dam by William F. Callahan of Bath, New Hampshire dated 1963. These plans are included as pages B-3 to B-5. It should be noted that these are not "As-Built" drawings and minor differences exist on the dam itself. Also available is correspondence between the New Hampshire Water Resources Board and the dam's owners regarding construction of the dam and emergency spillway capacity.

5.3 Experience Data

No records of flow or stage are known to be available for Olsen Dam or Waterman Brook.

5.4 Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires use of the discharge and storage characteristics of the structure to evaluate the impact of an appropriately sized Test Flood. The original hydraulic and hydrologic design calculations for Olsen Dam were not available.

Guidelines for establishing a recommended Test Flood based on the size and hazard classification of the dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1,000 acre-feet and the height of less than 40 feet classify this dam as a SMALL structure.

The appropriate hazard classification for this dam is HIGH because of the significant economic losses and potential for loss of life downstream in the event of failure of the dam. As shown in the Dam Failure Analysis section, the increase in flooding caused by the failure of Olsen Dam would cause the overtopping of Lower Mountain Lake Dam. Whether or not the earth embankment were to fail, the failure of Olsen Dam would cause significant damage to the public water supply pump station, a dirt back road, two houses and New Hampshire Highway 112 in addition to damage to Lower Mountain Lake Dam. There would be potential for loss of more than a few lives at the two houses.

As shown in Table 3 of the "Recommended Guidelines", the appropriate Test Flood for a dam classified as SMALL in size with a HIGH hazard potential would be between one-half of the Probable Maximum Flood (PMF) and the PMF. Since the risk downstream in the event of dam failure is on the low side of HIGH, half of the PMF is considered to be the appropriate Test Flood.

Using the chart of "Maximum Probable Flood Peak Flow Rates" for New England the half PMF peak inflow rate for Olsen Dam is 3,935 cfs, a rate of 1,175 cfs for the 3.35 square mile drainage area.

Attenuation due to storage in the reservoir results in a Test Flood routed peak outflow of 3,470 cfs, with the reservoir water surface at 782.4 feet MSL. This is 6.8 feet above the principal spillway crest, 4.1 feet above the emergency spillway crest and 0.8 feet above the dam crest. The spillway capacity (1640 cfs) is only 47 percent of the peak Test Flood outflow.

5.5 Dam Failure Analysis

The peak downstream flows that would result from the failure of Olsen Dam are estimated using the procedure suggested in E. Samuel Martin and Jerome J. Zoune's "Finite Difference Simulation of Bore Propagation", Journal of the Hydraulics Division, ASCE, Vol. 97, No. HY7, July 1971, pp. 993-1010. The failure is assumed to occur with the water surface at the dam crest, 781.6 feet MSL. The outflow prior to dam failure would be 1640 cfs, creating a tailwater elevation of 777.8 feet MSL in Lower Mountain Lake downstream of the dam.

For an assumed breach width equal to 40 percent of the dam width at the half height, the gap in the embankment due to dam failure would be about 230 feet. Use of Martin and Zoune's methodology for this situation gives a peak failure outflow of 13,375 cfs.

This dam failure flood wave would immediately enter Lower Mountain Lake. Prior to the failure of Olsen Dam, Lower Mountain Lake would have 0.2 feet of freeboard - the additional flow caused by the failure of Olsen Dam would cause Lower Mountain Lake Dam to be overtopped by 1.4 feet. The storage in Lower Mountain Lake would attenuate the peak dam failure flow to 7000 cfs.

The degree of overtopping described would probably damage and perhaps destroy the embankment of Lower Mountain Lake Dam. However, for the purposes of these calculations it will be assumed that Lower Mountain Lake Dam remains intact.

The peak failure outflow of 7000 cfs would cause the stage just downstream of Lower Mountain Lake Dam to increase from 4 feet to 9-10 feet which would damage or destroy the pump station located just downstream of the dam.

The next development to be affected by the dam failure flood wave would be Goose Pond Road which would be overtopped before failure and very severely overtopped after failure.

Further downstream is a house 3,300 feet downstream of Lower Mountain Lake Dam 5,800 feet downstream of Olsen Dam. The house is 5 feet above the streambed, and could be slightly damaged by the prefailure stage of 5 feet. The attenuated peak dam failure outflow of 5700 cfs would increase the stage to about 9 feet, causing 4 feet of flooding at the house and presenting a threat of loss of life.

Flow in the draw along which the other house in this area is located would increase from a trace to 4 to 5 feet. This would cause 2 to 3 feet of flooding at the house and present a threat of loss of life.

Downstream of these two houses and about 3,500 feet from Lower Mountain Lake Dam (6,000 feet from Olsen Dam), Waterman Brook and the draw both cross New Hampshire Highway 112. The prefailure flow of 1640 cfs would overtop the bridge on which the highway crosses Waterman Brook and possibly cause damage. The peak dam failure outflow of 5640 cfs would cause extensive damage to the bridge and the roadway embankment in the vicinity of the bridge.

Less than 100 feet downstream of New Hampshire Highway 112, Waterman Brook enters the Wild Ammonoosuc River. The river is a considerably larger stream than Waterman Brook, and dam Failure flows would begin to attenuate. The river is paralleled by Highway 112 for the 1.5 miles from Waterman Brook to U.S. Highway 302. The only structure in this reach is a single house, which is well above the river and out of flooding danger. Less than 0.5 miles downstream of U.S. Highway 302, the Wild Ammonoosuc joins the Ammonoosuc River, an even larger stream in which dam failure flows would rapidly attenuate.

The chart on the following page summarizes the downstream impacts of the failure of Olsen Dam.

Location & Number (see map)	Distance Downstream of Dam (ft.)	# of Structures	Level above Stream (ft.)	Flow & Stage Before Failure	Flow & Stage After Failure	Comments
just below dam	-	-	-	1640 cfs	13,375 cfs	Outflow directly to Lower Mountain Lake.
1. Lower Mountain Lake Dam	2500	-	-	1640 cfs 777.8 ft msl	700 cfs 779.4 ft msl	Dam overtopped by 1.4 feet, failure or damage possible.
just below Lower Mountain Lake Dam	2500	1 pump station	6	1640 cfs 4 ft.	7,000 cfs 9 ft.	Damage to pumphouse.
Goose Pond Road	3700	bridge	8'x 6' culvert	1640 cfs	6,370 cfs	Roadway embankment overtopped before failure. Certainly damaged or destroyed after failure.
2. House 200 ft. upstream of Highway 112	5800	1 house	5	1640 cfs 5 ft.	5,700 cfs 9 ft.	4 ft. of flooding at the house - serious threat of loss of life.
2. Draw from Waterman Brook to Highway 112	6000	1 house	2	trace	4-5 ft.	2-3 ft. of flooding at the house - serious threat of loss of life.
3. Highway 112	6000	1 bridge	5'x 10'	-	-	Bridge overtopped and possibly damaged before failure. Serious damage t bridge and roadway embankment after failure.
3. Juncture with Wild Ammonoosuc River	6100	-	-	1640 cfs	5,640 cfs	Larger river would begin t attenuate flood wave. No further serious damage anticipated.

Section 6: Structural Stability

6.1 Visual Observations

There does not appear to be significant displacement or distress. The riser structure appears stable with no evidence of distress. The outlet conduit appears to be structurally sound.

6.2 Design and Construction Data

No records of structural stability analyses are available for this dam.

6.3 Post Construction Changes

There have been no known changes to any of the embankments or structures.

6.4 Seismic Stability

The dam is located in seismic zone No. 2 and, in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

Section 7: Assessment, Recommendations and Remedial Measures

7.1 Dam Assessment

(a) Condition

The dam is in fair condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgement.

(c) Urgency

The remedial measures and improvements described herein should be implemented by the owner within one year of receipt of this Phase I Inspection Report.

7.2 Recommendations

A qualified registered professional engineer should be retained by the owner to perform a detailed hydraulic and hydrologic study to determine overtopping potential. The owner should implement the findings of this study.

If and when the downstream reservoir is lowered, it is recommended that the services of a qualified registered professional engineer be retained to evaluate the condition of the downstream slope and the outlet conduit which are presently submerged.

7.3 Remedial Measures

It is recommended that the owner institute the following remedial measures:

1) Implement and intensify a program of diligent and periodic maintenance including, but not limited to: mowing brush on slopes; backfilling animal burrows or tire ruts with suitable well tamped material; cleaning debris from spillways, trash racks, and slopes.

2) Regrade the upstream and downstream slopes and place some form of slope protection.

3) Develop a written downstream flood warning system to monitor conditions at the dam during and immediately after periods of heavy rain and to alert the appropriate officials and downstream residents in the event of an emergency.

4) Develop and maintain a program of annual technical inspections.

5) Provide a workable means of lowering the reservoir in the event of an emergency.

6) Curtail the future placement of recreational equipment or roadway embankment material in the emergency spillway channel.

remove

7.4 Alternatives

There are no meaningful alternatives to the above recommendations.

Inspection Team Organization

DATE: May 6, 1980

PROJECT: NH 00190
Olsen Dam
Haverhill, New Hampshire
NHWRB No. 112.09

WEATHER: Clear, warm

Inspection Team

Nicholas A. Campagna	Goldberg Zoino & Associates, Inc.	Team Captain
Jeffrey M. Hardin	Goldberg Zoino & Associates, Inc.	Soils
Andrew Christo	Andrew Christo Engineers	Structures
Paul Razgha	Andrew Christo Engineers	Structures
Carl Razgha	Andrew Christo Engineers	Structures

New Hampshire Water Resources Board
Representative Present: Mr. Pattu Kesavan

Tom Gooch and Richard Laramie of Resource Analysis Inc. performed the hydrologic inspection of this dam on June 11, 1980.

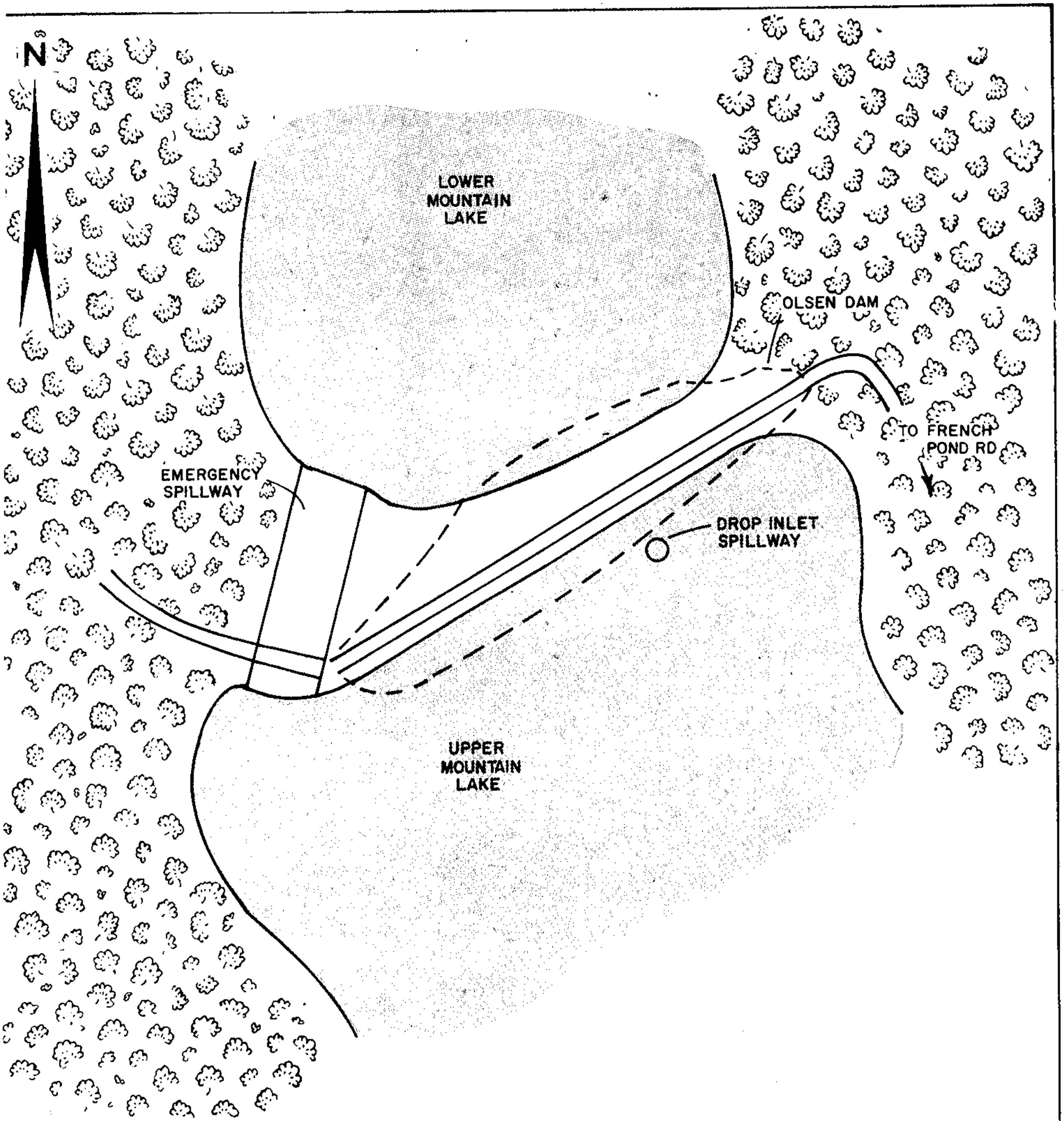
CHECKLISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT	NAC	
Crest Elevation		781.6 feet (MSL)
Current Pool Elevation		Approximately 775.6 ft.
Maximum Impoundment to Date		Unknown
Surface Cracks		None noted
Pavement Condition		Not Applicable
Movement or Settlement of Crest		None noted
Lateral Movement		None noted
Vertical Alignment		Good
Horizontal Alignment		Good
Condition at Abutment and at Concrete Structures		Good
Indications of Movement of Structural Items on Slopes		None
Trespassing on Slopes		Animal burrows in downstream slope (approximately mid length 5 ft. below crest)
Vegitation on Slopes		Few small bushes on upstream slope near water line.
Sloughing or Erosion of Slopes or Abutments		Evidence of 2 to 3 inches of undercutting due to wave action on the upstream slope.
Rock Slope Protection -- Riprap Failures		None
Unusual Movement or Cracking at or Near Toes		None noted
Unusual Embankment or Downstream Seepage		Lower portion of downstream slope submerged - could not observe.
	NAC	

CHECKLISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Piping or Boils	NAC	Lower portion of the downstream slope submerged, could not observe.
Foundation Drainage Features		None noted
Toe Drains		None noted
Instrumentation System	NAC	None noted
Principal Spillway	PR	
Reservoir Discharge Conduit		Submerged - could not observe
Outlet Conduit	PR	Submerged - could not observe

APPENDIX B

ENGINEERING DATA



GOLDBERG-ZOINO & ASSOCIATES, INC. GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS NEWTON UPPER FALLS, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

SITE PLAN

FILE No.2605

OLSEN DAM — NEW HAMPSHIRE

SCALE SCHEMATIC

DATE AUGUST 1980

PLAN OF DAM

SCALE: 1" = 100'

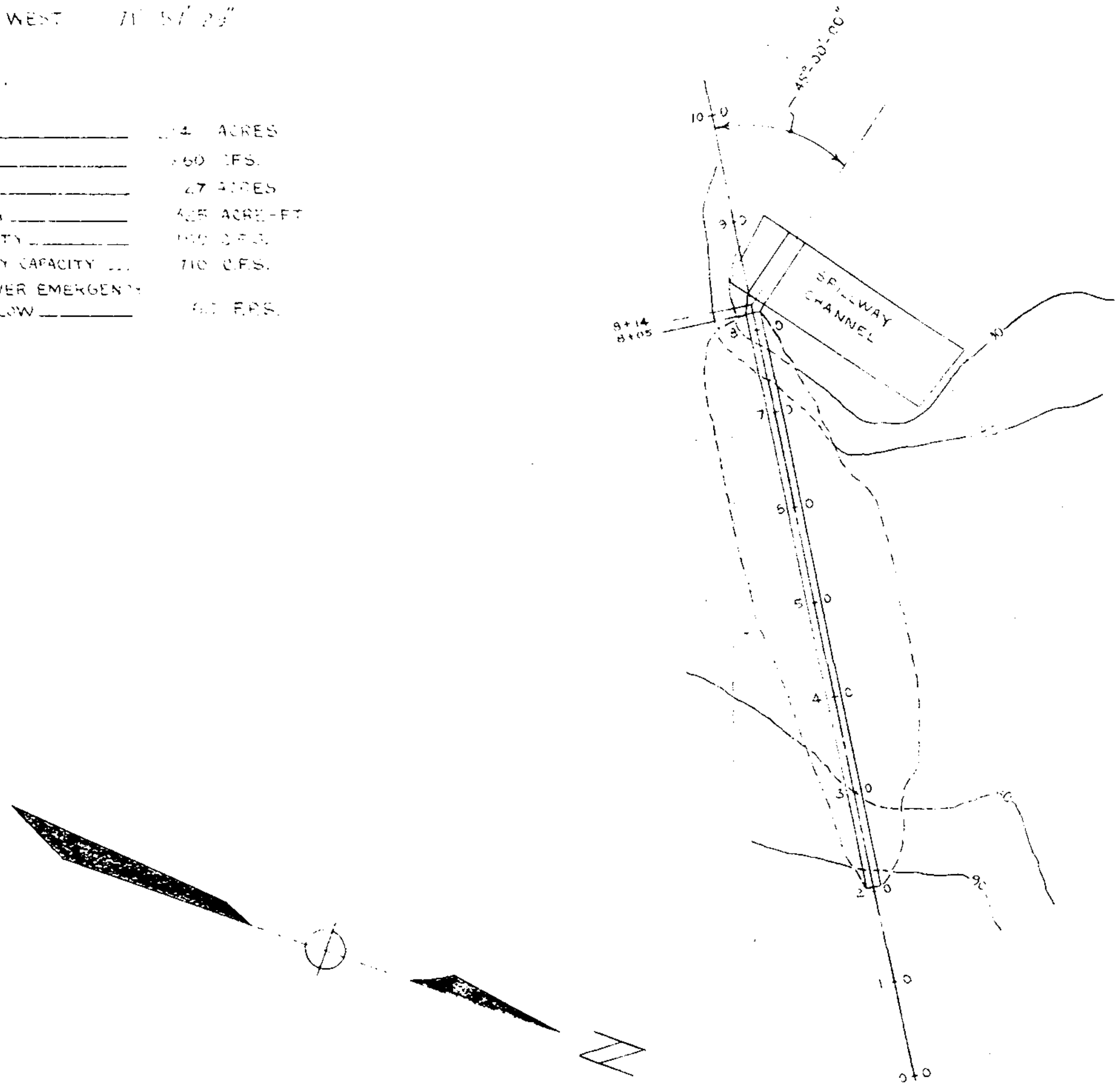
LOCATION

MOOSILAUKE N.H. QUAD SHEET U.S.G.S.

LATITUDE NORTH 44°-07'-15"

LONGITUDE WEST 71°-57'-23"

DRAINAGE AREA	[illegible] ACRES
DESIGN RUNOFF	[illegible]60 CFS.
POND AREA	[illegible]7 ACRES
RESERVOIR CAPACITY	[illegible] ACRE-FT
PRINCIPAL SPILLWAY CAPACITY	[illegible] C.F.S.
VEGETATED SPILLWAY CAPACITY	710 C.F.S.
VELOCITY OF FLOW OVER EMERGENCY SPILLWAY AT PEAK FLOW	[illegible] F.P.S.



NOTE:

ELEVATIONS ARE REFERENCED TO AN UNKNOWN DATUM

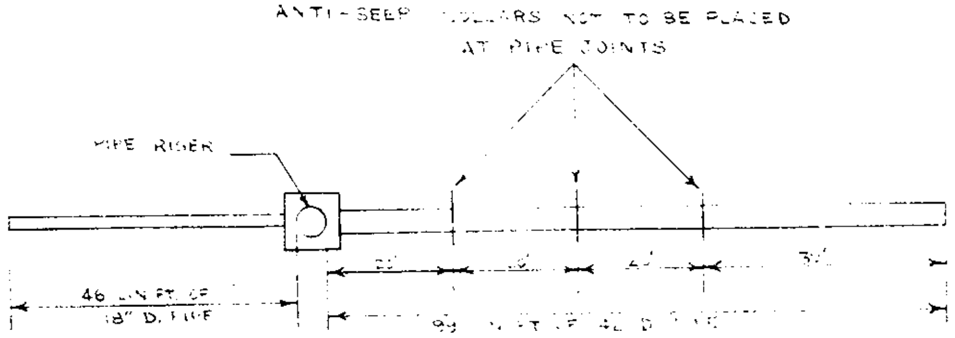
DEC 12 1963

NEW HAMPSHIRE WATER RESOURCES BOARD

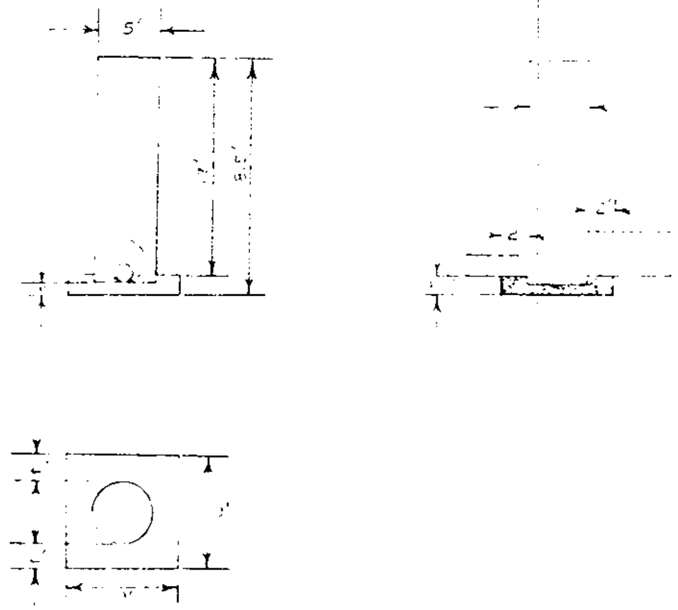
PLAN OF DAM

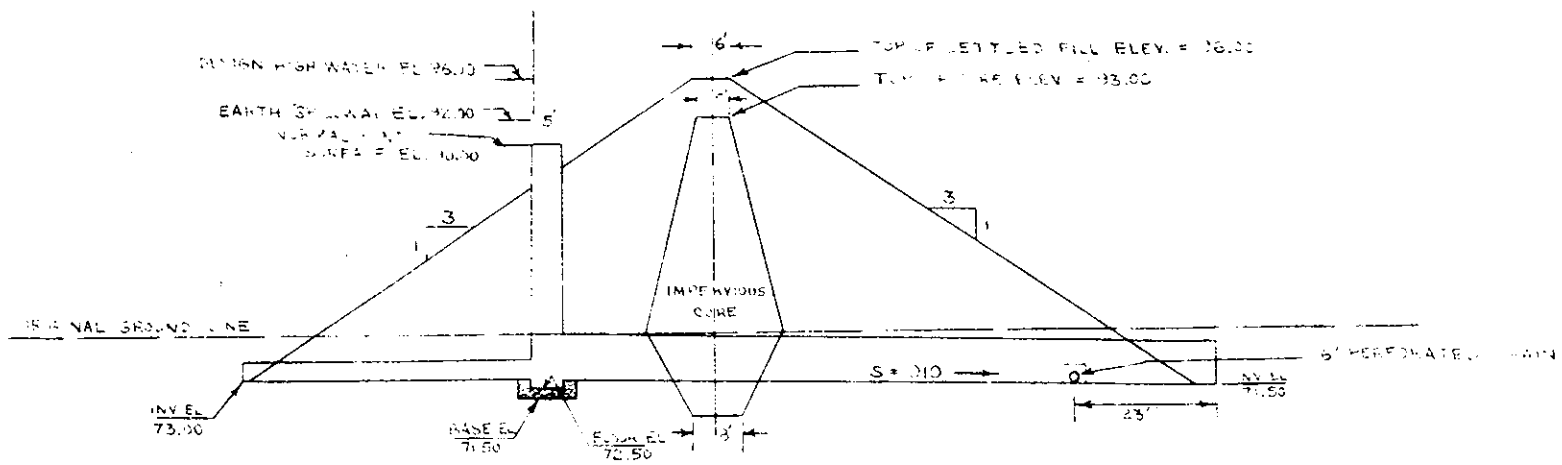
HAVERH[illegible] N.H.

K. BRUCKNER



PLAN OF PIPE SPILLWAY

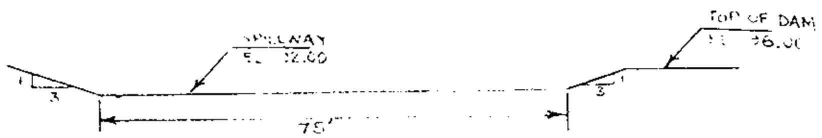




SCALE: HOR. 1" = 20'
VERT. 1" = 10'

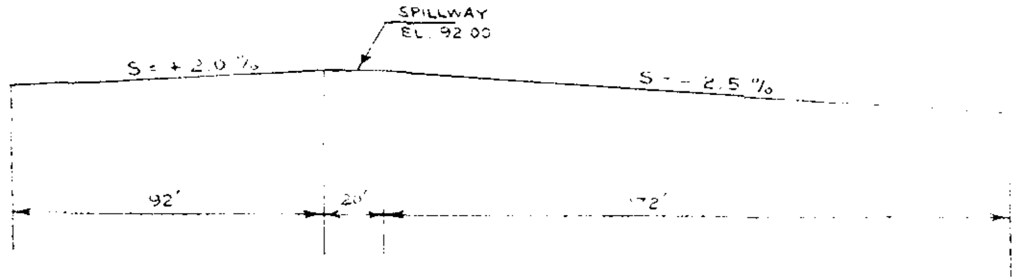
NOTE:
ELEVATIONS ARE REFERENCED TO AN UNKNOWN DATUM

DEC 12 1963
NEW HAMPSHIRE
WATER RESOURCES BOARD



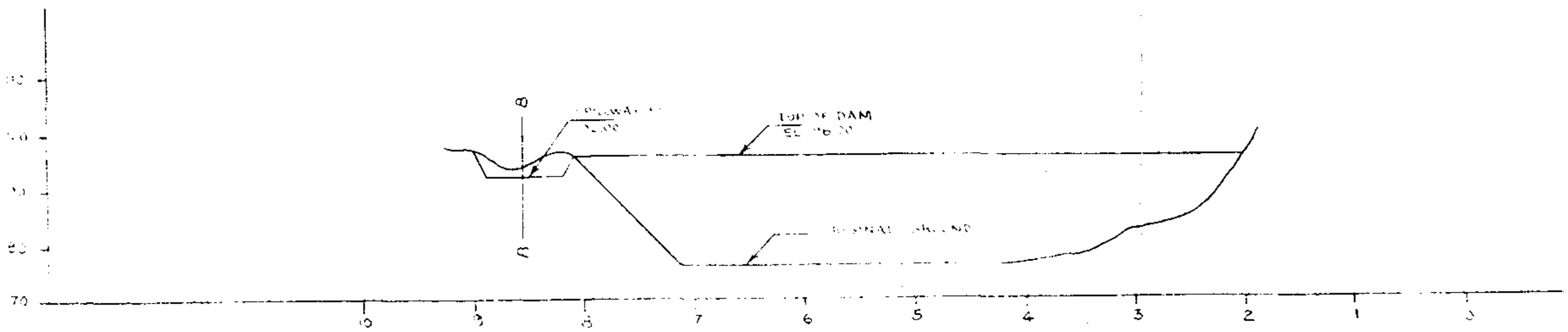
CROSS SECTION OF EMER... SPILLWAY

SCALE: HOR. 1" = 20'
VERT. 1" = 20'



B-B PROFILE OF EMER... SPILLWAY

SCALE: HOR. ... NE
VERT. ...



PROFILE AT ¢ OF DAM AND EMERGENCY SPILLWAY

SCALE: HOR. 1" = 100'
VERT. 1" = 10'

NOTE:
ELEVATIONS ARE REFERENCED TO AN UNKNOWN DATUM

PLAN OF DAM

IN

HAVERHILL ... N.H.

FOR

DEC 1...

WATE...

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Haverhill Dam Number: 112.09

Inspected by: SCB Date: 25 July 1974

Local name of dam or water body: ____

Owner: ____ Address: ____

Owner was/was not interviewed during inspection.

Drainage Area: ____ sq. mi. Stream: ____

Pond Area: 34 Acre, Storage ____ Ac-Ft. Max. Head ____ Ft.

Foundation: Type ____, Seepage present at toe - Yes/No, ____

Spillway: Type Emergency & Pipe, Freeboard over perm. crest: ____,

Width 100± 4' Dia, Flashboard height ____,

Max. Capacity ____ c.f.s.

Embankment: Type Earth, Cover Gravel Width 20' ±,

Upstream slope 2 to 1; Downstream slope 2 to 1

Abutments: Type ____, Condition: Good, Fair, Poor

Gates or Pond Drain: Size ____ Capacity ____ Type ____

Lifting apparatus ____ Operational condition ____

Changes since construction or last inspection: ____

Downstream development: ____

This dam would/would not be a menace if it failed.

Suggested reinspection date: ____

Remarks: ____

9279

AMPSHIRE
RESOURCES
OARD
ORD, N. H

PROJECT Dam 112.09 in Haverhill FILE

SUBJECT ACC.

COMPUTOR F.C.M. CHECKER CONT. FROM ACC. CONT. ON ACC. SUMMARY ON ACC. DATE 8/9/63

D.A. = 3.49 sq.mi.
Av. Elev = 441 feet
Av. Travel = 2.25 mi.

$$Q = [(3.44 \times 4.41 \times 21) + 200] \frac{3.49^{0.85}}{\sqrt{2.25}}$$

$$= [319 + 200] \frac{2.92}{1.5} = 529 \times 1.95 = \underline{1030 \text{ cfs}}$$

100 Year Frequency Flood Flow is 1030 cfs. (Knowlton roughly checked as 860 cfs)

Design Discharge is 663 cfs according to his statement but I think it is about 493 cfs.
No allowance for storage was taken into account.

Available storage was 325 ac-ft. but pond probably won't be empty when storm hits.
Actual Storage would be about 60 ac-ft. or 1/3" on drainage area.

From my figures, it would appear that the emergency spillway should be: $\frac{880 \quad 75}{330}$ or 200 feet long not 75 feet long.

However, if the embankment was raised 1', the capacity of emergency spillway (with 12" freeboard at 100 Yr Frequency Flood Flow) would be about 700 cfs. Therefore, the emergency spillway should be lengthened to 95 feet. Raising dam by 1 foot would increase the earthwork by about 2,300 c.y.

Submitted plans are not safe for a 100 Year Frequency Flood Flow even with no freeboard. However, if the dam was raised one foot, it seems that the proposed 75' emergency spillway would be adequate with about 9" freeboard.

HAVERHILL - W[illegible]

112.09

AUG 7 1963

NEW HAMPSHIRE
WATER RESOURCES BOARD

Form WCC. 1
7/30/37

THE STATE OF NEW HAMPSHIRE

County of GRAFTON, ss. AUG 6, 1963

PETITION FOR APPROVAL OF THE CONSTRUCTION OR

REPAIR OF DAM AT HAVERHILL N.H.

TO THE WATER CONTROL COMMISSION:

In complirnce with the provisions of Laws of 1937, c. 133, an Act establishing a Water Control Commission,

We, M. OLSEN, L. CASTELLO, K. BRUCKNER
I, (Here state name of person or persons, partnership, association, corporation,

etc.)

hereby petition the Water Control Commission for approval to construct, ~~to reconstruct~~, ~~to make repairs~~ to, a dam along, ~~or~~ (cross out portion not applicable) across
(Here state name of stream or body of water)

WATERMAN BROOK

at a point APPROX 4 MI. from mouth of stream
(Here give location, by distance from mouth of stream, county

APPROX 1 MI South of BATH - HAVERHILL Ln
or municipal boundary)

in the town (s) of ON FRENCH POND ROAD HAVERHILL N.H

in accordance with PRELIMINARY PLANS, and SPECIFICATIONS FILED WITH THIS APPLICATION and made a part hereof.

Form WCC. 1-p. 2
7/30/37

The purpose of the proposed construction is ______________________
(Here briefly state use to

DEVELOPEMENT OF SHORE LOTS, FISH
which stored water is to be put)

PRODUCTION AND FIRE PROTECTION

The construction will consist of EARTH DAM IN ACCORDANCE
(Here give brief description of work con-

WITH PLANS ATTACHED
templated including height of dam)

All land to be flowed ~~is not~~ is owned by applicants

Morris Olsen

Address RFD #1
NORTH HAVERHILL, N.H.

Note: This application together with plans, specifications and information and data filed in connection herewith will remain on file in the office of the Water Control Commission.

M E M O R A N D U M

To: Leonard R. Frost, Water Resources Engineer

Subject: Petition for Approval to Construct a Dam in Haverhill, N. H. (Olsen)

Plans approved by Gordon R. Ingram, Professional Engineer, for a dam to be built by M. Olsen et al was received August 7, 1963 and analysed by me and roughly checked by Knowlton. The following comments are made:

(1) 100 year Frequency Flood Flow is 1030 cfs. on 3.5 sq. mi. drainage area (Knowlton roughed it as 860 cfs.).

(2) Submitted figures for emergency spillway capacity with 12" freeboard were 513 cfs. whereas both of us had about 330 cfs. I agreed closely with his 150 cfs. capacity for the principal spillway.

(3) To obtain the needed 1030 cfs. capacity either of two methods could accomplish this:

(a) Lengthen spillway from 75' to 200', or

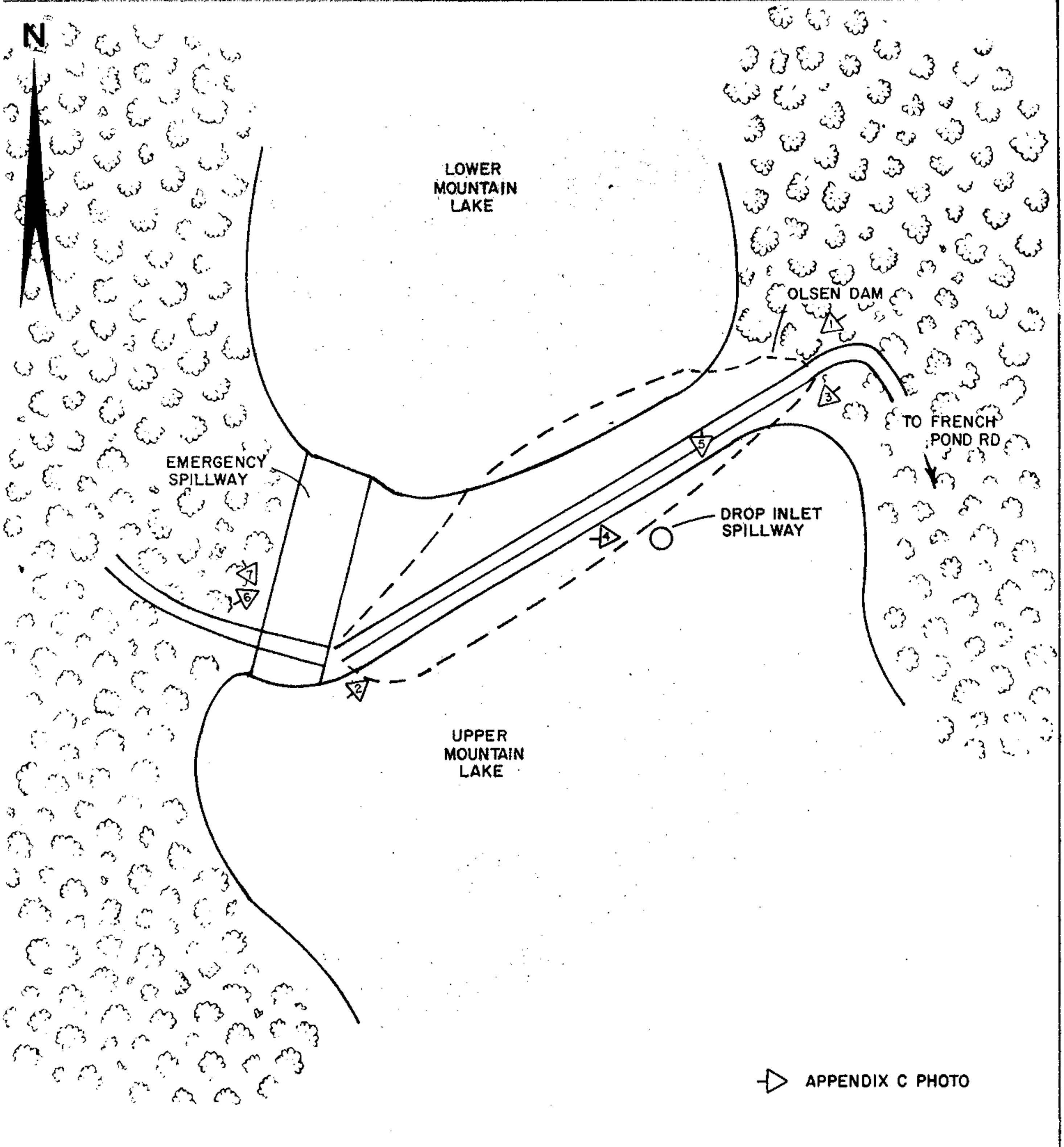
(b) Raise embankment by 12" and keep spillway same width which would still have about 9" freeboard. In this case the velocity in outlet channel would be about 6.6 f.p.s.

Francis C. Moore
Francis C. Moore
Civil Engineer

August 9, 1963

APPENDIX C

PHOTOGRAPHS



GOLDBERG · ZOINO & ASSOCIATES, INC. GEOTECHNICAL - GEOHYDROLOGICAL CONSULTANTS NEWTON UPPER FALLS, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

PHOTO LOCATION PLAN

FILE No. 2605

OLSEN DAM — NEW HAMPSHIRE

SCALE SCHEMATIC

DATE AUGUST 1980

1. Downstream slope from right abutment

2. Upstream slope from left end of embankment
Note minor undercutting of slope at water line

3. Upstream slope and principal spillway

4. Platform over drop inlet type
Principal spillway

5. Upstream waterline showing minimal erosion protection

6. Downstream end of emergency spillway from left abutment

7. Upstream end of emergency spillway from left abutment

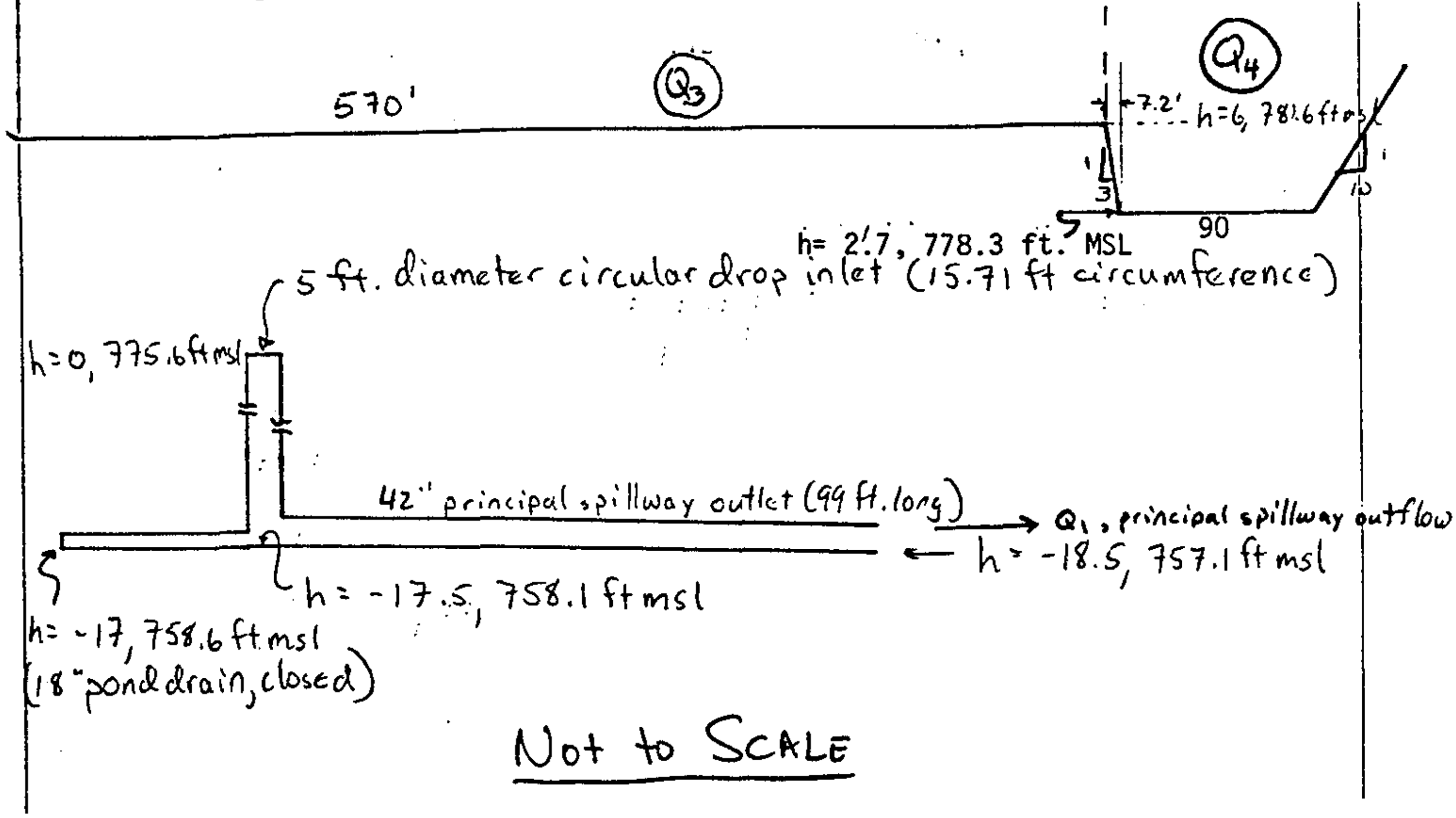
APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

OLSEN DAM

TCG
6/13/80

The elevation of Olsen Dam given below is based on field notes, dam plans, and USGS topo information. The dimensions shown approximate the stage/discharge characteristics of the dam.



Stage-Discharge Curve

Principal Spillway Flow, Q_1

The principal spillway is a five foot diameter circular riser with a circumference of 5π = 15.71 ft. and a crest elevation of 775.6 ft. msl (h=0.). (The crest elevation is determined from the elevation of the pond outlet downstream, which is 774 ft. msl. At the time of the inspection, this pond was 1.6 ft. higher than the one downstream. 774 + 1.6 = 775.6 ft. msl for the elevation of the Olsen Dam principal spillway crest.) The outlet from the riser is 42" RCP with a 1 foot drop in 100 ft. There is a second inlet to the riser - an 18" pond drain with an invert at 758.6 ft. msl (h = -17). The pond drain will be assumed to be closed for these calculations.

Flow through the principal spillway will occur in one of two modes at various lake levels:

Q_w (P_1 in BASIC program) = weir flow = 3.3 (15.71) $(h)^{3/2}$

Q_p (P_2 in BASIC program) = pipe flow

The lower flow of Q_w and Q_p will control outflow. Pipe flow will be under outlet control, since Lower Mountain Lake downstream "chokes" the pipe. An iterative scheme was used to calculate the pipe flow including the effects of downstream stage. Federal Highway Administration Hydraulic Engineering Circular No. 5 (Dec. 1965), "Hydraulic Charts for the Selection of Highway Culverts" allows calculation of flow for a given head. The chart on the following page summarizes the results of these calculations.

OLSEN DAM

TCG
6/13/80

h (ft.)	Olsen Dam Pond Elevation (u/s stage) (ft. msl)	Q_W [1.] Weir Flow (cfs)	Lower Mountain [2.] Lake Elevation (d/s stage) (ft. msl)	Q_p [3.] (cfs)	control (weir or pipe)	Q_1 (cfs)
0	775.6	0	774.0	-	-	0
1	776.6	52	774.9	71	weir	52
2	777.6	147	775.1	85	pipe	85
3	778.6	269	775.1	100	pipe	100
4	779.6	415	775.3	110	pipe	110
5	780.6	580	776.0	120	pipe	120
6	781.6	762	776.9	120	pipe	120
7	782.6	960	778.0 [4.]	120	pipe	120
7.5	783.1	1060	778.0 [4.]	120	pipe	120

Notes:

1. $3.3\ (15.71)\ (h)^{3/2}$
2. Depends on total Olsen Dam outflow and on Lower Mountain Lake stage-discharge curve given in separate report.
3. From page 5-32 in FHWA HEC-5, using u/s stage minus d/s stage as head.
4. The stage-discharge curve for Lower Mountain Lake does not extend to the flows at this elevation. Elevation of Lower Mountain Lake is assumed to be at dam crest.

OLSEN DAM

TCG
6/13/80

Emergency Spillway Flow, Q_4

SCS Technical Release #39, "Hydraulics of Broad Crested Spillways" allows computation of Q vs. H_{pool} for the emergency spillway. Figure ES-171 relates H_{pool} to H_{ec}, the head at the weir crest for a given spillway shape and flow length, taking into account head loss along the emergency spillway channel.

On page 16 of T.R. #39, the following equations relate H_{ec} to Q:

$$H_{ec} = \frac{(3b + 5zd)\ d}{2b + 4zd}$$

$$\frac{Q^2}{g} = \frac{\left[(b + zd)\ d\right]^3}{b + 2zd}$$

where

d = critical flow depth

z = side slopes = 3:1 and 10:1; 6.5:1 average

b = width = 90 ft.

l = length of flow path = 112 ft.

H_{pool} = head above spillway crest in pool, ft.

H_{ec} = head at spillway control section, ft.

Q = outflow, cfs

g = acceleration due to gravity = 32.2 ft/sec^2

so, $$H_{ec} = \frac{(270 + 32.5d)\ d}{180 + 26d} \qquad (1)$$

and $$\frac{Q^2}{g} = \frac{\left[(90 + 6.5d)\ d\right]^3}{90 + 13d} \qquad (2)$$

OLSEN DAM

TCG
6/13/80

Equations (1) and (2) may be related as shown below for Olsen Dam:

Emergency Spillway Rating Curve

h (ft.)	Elevation (ft. msl)	H_{pool} (ft. above em s/w crest)	H_{ec} (ft.) 1.	d (ft.) 2.	Q_4 (cfs) 3.
0	775.6	-	-	-	0
1	776.6	-	-	-	0
2	777.6	-	-	-	0
2.7	778.3	0	0	0	0
3	778.6	0.3	0.21	0.14	30
3.5	779.1	0.8	0.55	0.37	120
4	779.6	1.3	0.98	0.66	280
4.5	780.1	1.8	1.43	0.97	510
5	780.6	2.3	1.90	1.30	790
5.5	781.1	2.8	2.37	1.63	1130
6	781.6	3.3	2.84	1.97	1520
6.5	782.1	3.8	3.32	2.31	1960
7	782.6	4.3	3.80	2.66	2450
7.5	783.1	4.8	4.28	3.01	2990

Notes:

1. From H_{pool} using Figure ES-171, sheet 2 in T.R. #39.
2. From H_{ec} using Equation (1).
3. From d using Equation (2).

OLSEN DAM

TCG
6/13/80

Flow Over Top of Dam, $Q_2 + Q_3$

for $h \leq 6$

$$Q_2 = Q_3 = 0$$

for $h > 6$

$$Q_2 = 2.8\ (50(h-6))\ (.5(h-6))^{3/2}$$

$$Q_3 = 2.8\ (570)\ (h-6)^{3/2}$$

C = 2.8 for broad-crested earth weir

The BASIC program which follows calculates a stage-discharge curve, for Olsen Dam.

```
list
100 REM - STAGE/DISCHARGE CURVE FOR OLSEN DAM
110 REM - STORED ON TAPE B-1 FILE 11
120 PAGE
130 REM - THE D1 ARRAY CONTAINS EMERGENCY SPILLWAY O VS. H DATA
140 REM - N1 IS THE # OF O VS. H POINTS
150 N1=12
160 N2=9
170 DIM D1(2,N1),D2(2,N2)
180 DATA 0,2.7,3,3.5,4,4.5,5,5.5,6,6.5,7,7.5,0,0,30,120,280,510,790,1130
190 DATA 1520,1960,2450,2990
200 FOR I=1 TO N1
210 READ D1(1,I)
220 NEXT I
230 FOR I=1 TO N1
240 READ D1(2,I)
250 NEXT I
260 REM - THE D1 ARRAY CONTAINS PIPE O VS. H POINTS. N2 = # OF POINTS
270 DATA 0,1,2,3,4,5,6,7,7.5,0,52,85,100,110,120,120,120,120
280 FOR I=1 TO N2
290 READ D2(1,I)
300 NEXT I
310 FOR I=1 TO N2
320 READ D2(2,I)
330 NEXT I
340 PRINT USING 350:
350 IMAGE 10T"STAGE VS. DISCHARGE RELATIONSHIP FOR OLSEN DAM  "
360 PRINT USING 370:
370 IMAGE // 6T"HEAD"                    35T"DISCHARGE"
380 PRINT USING 390:
390 IMAGE 1T"(FT. ABOVE S/W)"37T"(CFS)"
400 PRINT ""
410 PRINT USING 420:
420 IMAGE 19T "TOTAL    PRINCIPAL S/W    EMERGENCY S/W    TOP OF DAM"
430 PRINT USING 440:
```

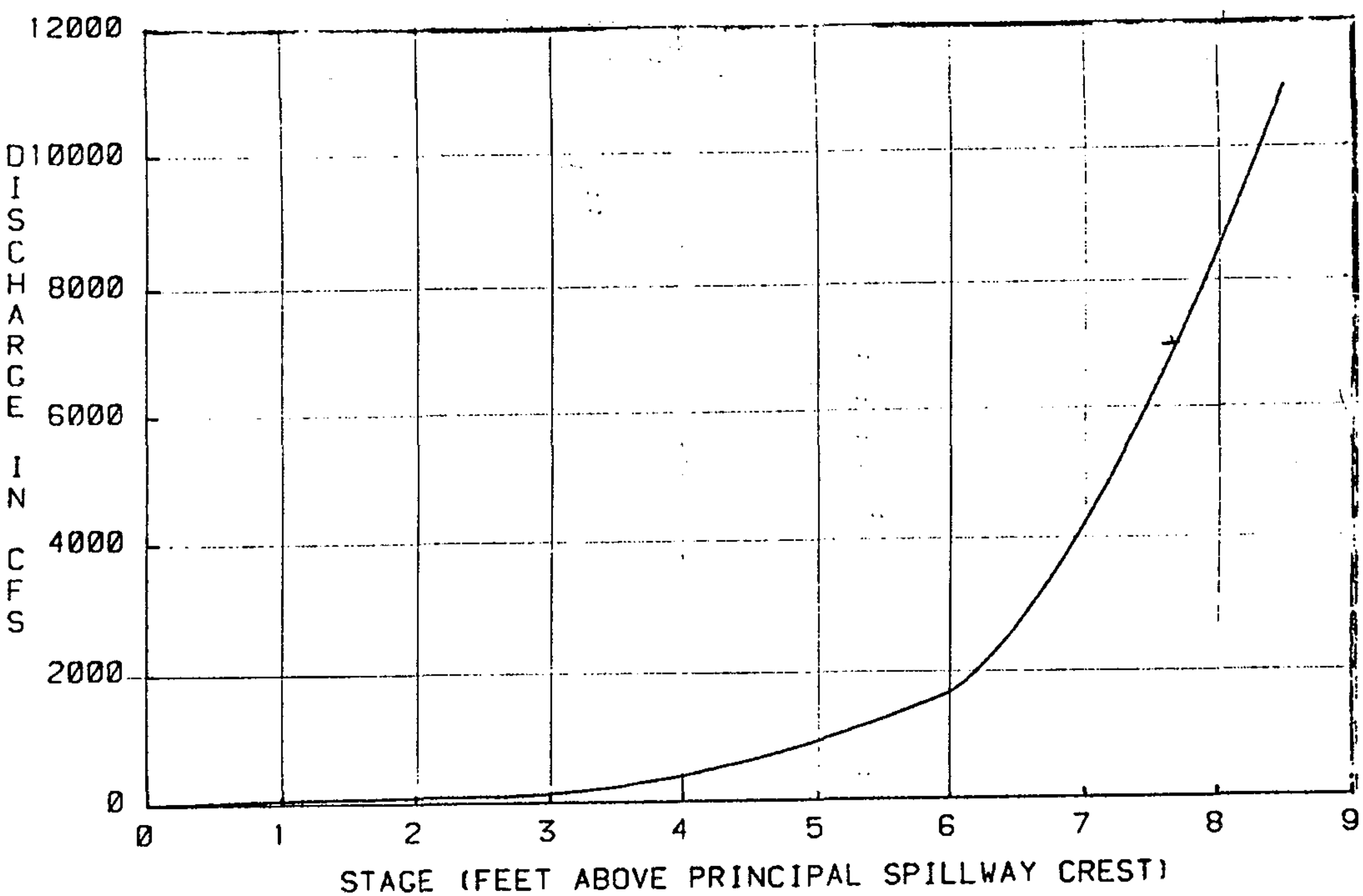
```
440 IMAGE 15T"(O1+O2+O3+O4)      (O1)            (O4)          (O2+O3)"
450 PRINT ""
460 FOR H=0 TO 8.5 STEP 0.5
470 O2=0
480 O3=0
490 O4=0
500 REM - P1 IS THE FLOW WHICH CAN PASS OVER THE RISER CREST
510 P1=3.3*15.71*H↑1.5
520 REM - O1 IS THE PRINCIPAL SPILLWAY OUTFLOW
530 O1=P1
540 REM - P2 IS THE FLOW WHICH CAN PASS THROUGH THE OUTLET PIPE
550 REM - PIPE FLOW (P2) DETERMINED BY LINEAR INTERPOLATION FROM D2
560 IF H<D2(1,N2) THEN 600
570 REM - LINEAR EXTRAPOLATION BEYOND RANGE OF D2 VALUES
580 P2=D2(2,N2)+(H-D2(1,N2))*(D2(2,N2)-D2(2,N2-1))/(D2(1,N2)-D2(1,N2-1))
590 GO TO 650
600 FOR I=1 TO N2
610 IF H=>D2(1,I) THEN 630
620 GO TO 640
630 NEXT I
640 P2=D2(2,I-1)+(D2(2,I)-D2(2,I-1))*(H-D2(1,I-1))/(D2(1,I)-D2(1,I-1))
650 IF P1<P2 THEN 670
660 O1=P2
670 IF H<2.7 THEN 820
680 REM - THE EMERGENCY SPILLWAY FLOW (O4) IS DETERMINED BY LINEAR
690 REM -    INTERPOLATION OF THE VALUES IN ARRAY D1.
700 IF H<D1(1,N1) THEN 740
710 REM - LINEAR EXTRAPOLATION BEYOND D1 CURVE
720 O4=D1(2,N1)+(H-D1(1,N1))*(D1(2,N1)-D1(2,N1-1))/(D1(1,N1)-D1(1,N1-1))
730 GO TO 790
740 FOR I=1 TO N1
750 IF H=>D1(1,I) THEN 770
760 GO TO 780
770 NEXT I
780 O4=D1(2,I-1)+(D1(2,I)-D1(2,I-1))*(H-D1(1,I-1))/(D1(1,I)-D1(1,I-1))
```

```
790 IF H<=6 THEN 820
800 O2=2.8*50*(H-6)*(0.5*(H-6))↑1.5
810 O3=2.8*570*(H-6)↑1.5
820 T1=O1+O2+O3+O4
830 T2=O2+O3
840 PRINT USING 850:H,T1,O1,O4,T2
850 IMAGE 6D.2D,14D,13D,17D,14D
860 NEXT H
870 END
```

STAGE VS. DISCHARGE RELATIONSHIP FOR OLSEN DAM

HEAD (FT. ABOVE S/W)	DISCHARGE (CFS)			
	TOTAL (O1+O2+O3+O4)	PRINCIPAL S/W (O1)	EMERGENCY S/W (O4)	TOP OF DAM (O2+O3)
0.00	0	0	0	0
0.50	18	18	0	0
1.00	52	52	0	0
1.50	69	69	0	0
2.00	85	85	0	0
2.50	93	93	0	0
3.00	130	100	30	0
3.50	225	105	120	0
4.00	390	110	280	0
4.50	625	115	510	0
5.00	910	120	790	0
5.50	1250	120	1130	0
6.00	1640	120	1520	0
6.50	2653	120	1960	573
7.00	4215	120	2450	1645
7.50	6178	120	2990	3068
8.00	8444	120	3530	4794
8.50	10988	120	4070	6798

STAGE-DISCHARGE CURVE AT OLSEN DAM



OLSEN DAM

TCG
7/8/80

The storage behind Olsen Dam at the spillway crest (h=0, 775.6 ft. msl) is 325 ac-ft. The surface area of the pond behind Olsen Dam is 27 acres. Assuming no spreading as the pond rises:

Surcharge storage = 27h

Total Storage = 325 + 27h

For the drainage area of 2146 acres (= 3.35 sq. mi.):

$$1'' \text{ of runoff} = \frac{2146 \text{ acres } (1'')}{12(''/\text{ft})} = 179 \text{ ac-ft.}$$

1 ac-ft. = 1/179 = .0056 " of runoff

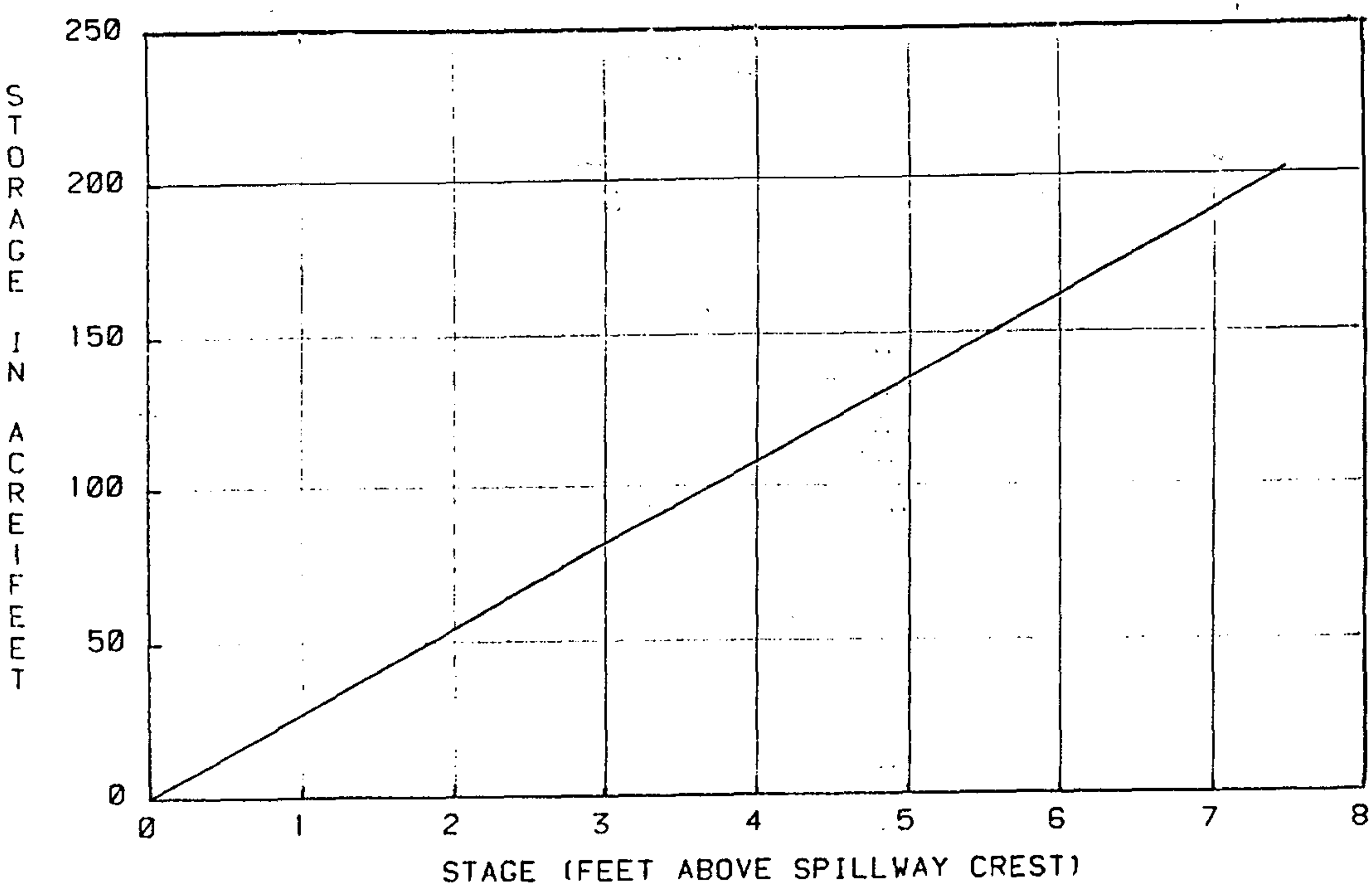
Surcharge storage to the dam crest = 6(27)

= 162 ac-ft. = .91" of runoff.

At the dam crest, total storage = 325 + 162 = 487 ac-ft.

The stage-storage curve is given on the next page.

STAGE-SURCHARGE STORAGE CURVE FOR OLSEN DAM



D-14

OLSEN DAM

DAM FAILURE ANALYSIS

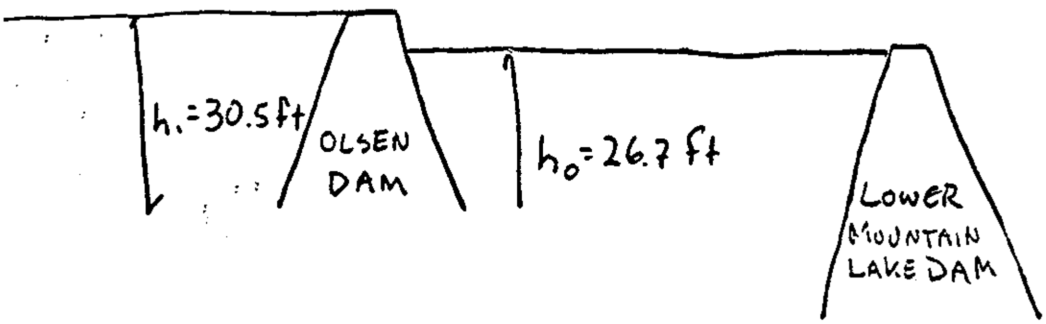
Assume failure when the water overtops the dam crest at h=6, 781.6 ft. MSL.

Normal outflow = 1640 cfs

Breach Outflow: The normal outflow of 1640 cfs would create a Water surface of 778.8 MSL in Lower Mountain Lake Dam, according to the stage-discharge curve in the separate report on that dam. This is 0.2 feet below the dam crest.

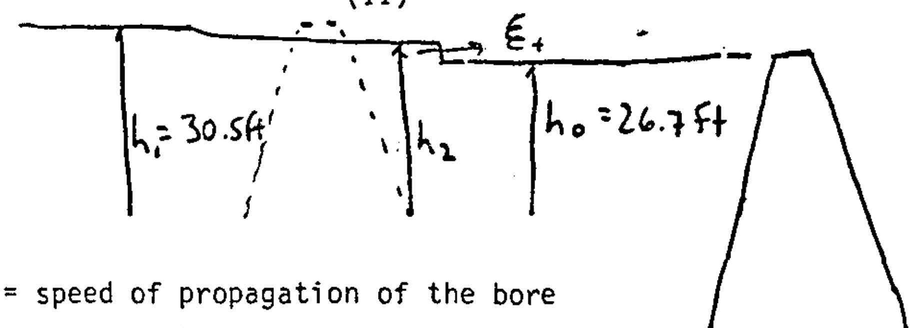
This high tailwater creates the situation shown below:

(I)



For this type of pre-failure condition Martin and Zovne, in an article attaches as pages D-27 through D-36 of this appendix, suggest that failure will result in formation of a bore as shown below:

(II)



Where: ξ_+ = speed of propagation of the bore
Q = flow at the dam site
V_2 = velocity at the dam site

Martin and Zovne's analysis gives these relationships:

$$\beta = \sqrt{\tfrac{1}{2}\,\frac{h_2}{h_0}\left(1 + \frac{h_2}{h_0}\right)}$$, where β has no <u>physical</u> significance

$$\beta - \frac{1}{4\beta}\left(1 + \sqrt{1 + 8\beta^2}\right) + \sqrt{2}\left(\sqrt{1 + 8\beta^2} - 1\right)^{\frac{1}{2}} = 2\sqrt{\frac{h_1}{h_0}}$$

$$\xi_+ = \sqrt{g\,\frac{h_2}{h_0}\left(\frac{h_0 + h_2}{2}\right)}$$

$$V_2 = \left(1 - \frac{h_0}{h_2}\right)\xi_+$$

$Q = V_2\,h_2 B$ where B = failure width

To solve this for Olsen Pond:

$h_1 = 30.5$, $h_o = 26.7$

so $\beta - \frac{1}{4\beta}\left(1 + \sqrt{1 + 8\beta^2}\right) + \sqrt{2}\left(\sqrt{1 + 8\beta^2} - 1\right)^{\frac{1}{2}} = 2\sqrt{\frac{30.5}{26.7}} = 2.138$

β	Solution
1	2
1.05	2.132
1.06	2.158
1.052	2.137

so $\beta = 1.052$

$$\beta = 1.052 = \sqrt{\tfrac{1}{2}\frac{h_2}{h_0}\left(1+\frac{h_2}{h_o}\right)} = \sqrt{\tfrac{1}{2}\frac{h_2}{26.7}\left(1+\frac{h_2}{26.7}\right)}$$

h_2	Solution
29	1.064
29.2	1.070
28.6	1.053

so h_2 = 28.6 ft.

Solve for $\xi_+ = \sqrt{g\frac{h_2}{h_0}\left(\frac{h_0+h_2}{2}\right)} = \sqrt{g\frac{28.6}{26.7}\left(\frac{28.6+26.7}{2}\right)} = 30.882$

Solve for $V_2 = \left(1-\frac{h_0}{h_2}\right)\xi_+ = \left(1-\frac{26.7}{28.6}\right)30.882 = 2.052$ ft/s

$Q = V_2h_2B = 58.676B$. $\quad B = .4$(width at ½ height of dam $= .4(500) = 200$ ft.

$Q = 58.676(200) = 11{,}735$ cfs

PEAK FAILURE OUTFLOW = 1640 + 11,735 = 13,375 cfs

Immediately downstream of Olsen Dam is the pond created by Lower Mountain Lake Dam. The 0.2 feet of freeboard left in this dam contains about 0.2(70) = 12 ac-ft. of storage. The peak outflow from the dam with the water surface at the dam crest is given as 1765 cfs in the separate report on that dam.

The storage behind Olsen Dam above the tailwater elevation is 27(4.7)= 127 ac-ft. Using the suggested test flood attenuation guidelines, the storage in Lower Mountain Lake below the dam crest would reduce the peak flow from the failure of Olsen Dam to:

$$Q_{p2} = 13,375\ (1 - \frac{12}{127}) = 12,100 \text{ cfs}$$

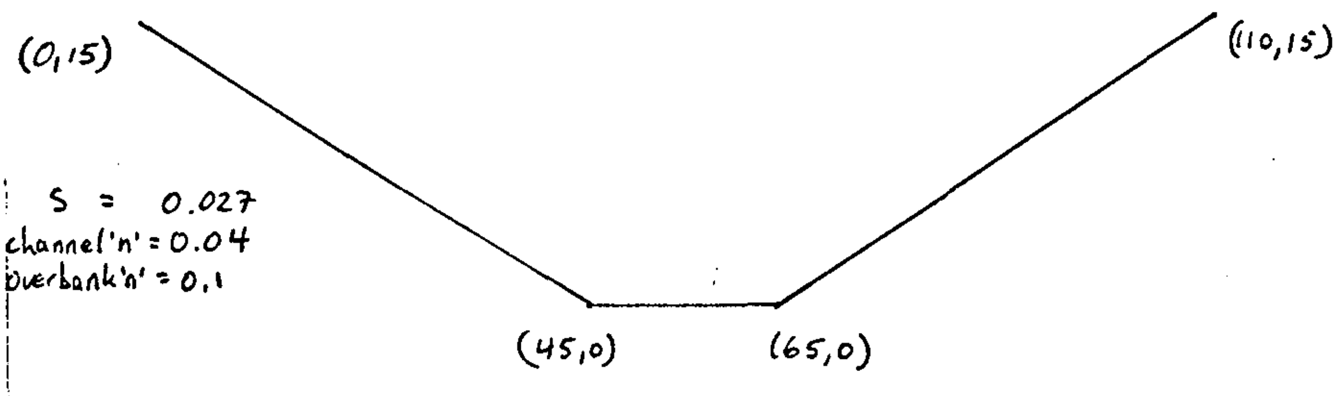
This is much greater than the 1765 cfs outflow capacity of Lower Mountain Dam, so the dam would be overtopped by flow from the failure of Olsen Dam.

It is reasonable and consistent to assume that overtopping of the earth embankment of Lower Mountain Lake Dam might cause failure to that dam. We will assume the failure to occur when the water surface overtops the dam at elevation 778 ft. MSL.

Normal outflow = 1765

Breach outflow = $Q_{p1} = 8/27\sqrt{g}\ \ W_b\ (Y_0)^{3/2}$

According to the separate report on Lower Mountain Lake Dam, the breach flow would be 15,826 cfs. Peak failure flow = 1765 + 15,826 = 17,600 cfs. The following stream section is typical of the reach from lower Mountain Lake Dam for about 2200 ft. downstream.



A stage-normal flow relationship for this reach is given on the next page. The outflow before the failure of either dam, 1640 cfs, would create a stage of about 4.3 feet.

The storage behind the dam at failure would be the combined storage of the two ponds. Olsen Pond contained 487 ac-ft. at its failure, and Lower Mountain Lake some 934 ac-ft. Thus total storage would be 1420 ac-ft.

This is enough storage to ensure that the failure flood wave would not attenuate significantly in the 0.6 mile reach of Waterman Brook down to the Wild Ammonoosuc River.

The peak dam fialure outflow of 17,600 would increase the stage downstream of the Lower Dam to about 15 ft., which would destroy the water intake located just downstream of the dam.

In the 1500 reach downstream of the dam, the only development is Goose Pond Road, which crosses Waterman Brook on a dirt embankment with an 8 ft. by 6 ft. corrugated metal arch culvert. The road embankment would be seriously damaged or destroyed by dam failure flows.

===== DATA FOR THE COMBINED SYSTEM =====

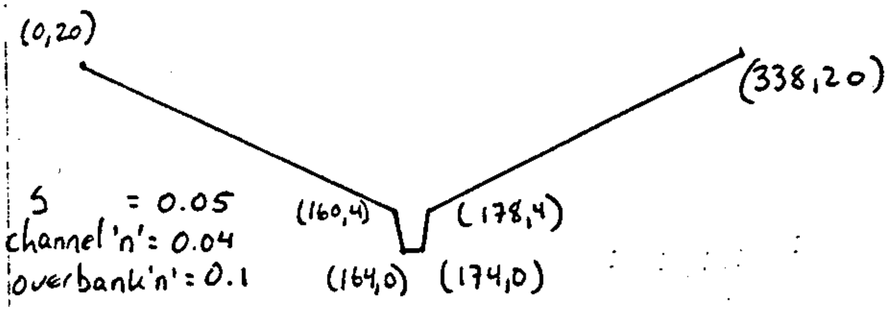
DEPTH ft.	ELEV ft.	AREA ft↑2	WPER ft.	HYD-R ft.	AR2/3	Q cfs
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.50	0.5	10.8	23.2	0.5	6.4	39.3
1.00	1.0	23.0	26.3	0.9	21.0	126.9
1.50	1.5	36.8	29.5	1.2	42.6	253.8
2.00	2.0	52.0	32.6	1.6	70.9	417.0
2.50	2.5	68.8	35.8	1.9	106.2	615.2
3.00	3.0	87.0	39.0	2.2	148.6	847.6
3.50	3.5	106.8	42.1	2.5	198.4	1113.9
4.00	4.0	128.0	45.3	2.8	255.8	1414.0
4.50	4.5	150.8	48.5	3.1	321.2	1748.2
5.00	5.0	175.0	51.6	3.4	394.9	2116.4
5.50	5.5	200.8	54.8	3.7	477.1	2519.1
6.00	6.0	228.0	57.9	3.9	568.2	2956.4
6.50	6.5	256.8	61.1	4.2	668.5	3428.9
7.00	7.0	287.0	64.3	4.5	778.3	3937.0
7.50	7.5	318.8	67.4	4.7	897.8	4480.9
8.00	8.0	352.0	70.6	5.0	1027.3	5061.3
8.50	8.5	386.8	73.8	5.2	1167.3	5678.5
9.00	9.0	423.0	76.9	5.5	1317.9	6333.1
9.50	9.5	460.8	80.1	5.8	1479.4	7025.4
10.00	10.0	500.0	83.2	6.0	1652.1	7756.2
10.50	10.5	540.8	86.4	6.3	1836.4	8525.7
11.00	11.0	583.0	89.6	6.5	2032.4	9334.6
11.50	11.5	626.8	92.7	6.8	2240.5	10183.3
12.00	12.0	672.0	95.9	7.0	2460.9	11072.4
12.50	12.5	718.8	99.1	7.3	2693.9	12002.3
13.00	13.0	767.0	102.2	7.5	2939.7	12973.7
13.50	13.5	816.8	105.4	7.8	3198.7	13986.9
14.00	14.0	868.0	108.5	8.0	3471.1	15042.6

Stage vs. Normal Flow for the First 1500 feet of Waterman Brook below Lower Mountain Lake

OLSEN DAM

TCG
7/8/80

The next development on Waterman Brook is about 200 ft. upstream of State Highway 112, about 3300 ft. downstream of Lower Mountain Lake Dam. The stream in this area can be represented by this cross-section:



A stage-normal flow relationship for this reach is given on the following page.

There is one house in this area on the banks of the stream, about 5 ft. above the channel bottom.

The flow before the failure of either upstream dam, 1640 cfs, would cause a stage of 5.3 ft. After the failure of both upstream dams, the peak flow of 17,600 cfs would increase the stage to 13.5 ft. or 8-9 ft. of flooding at the house. This would present a threat of loss of life at the house.

Just downstream of the house is a draw, about 5 feet above the stream channel, leading to Highway 112. This draw is normally dry, but dam failure flows would cause 7-9 feet of flow. About 200 feet downstream of the beginning of the draw is a house within 2 feet of the draw channel bottom. Dam failure would cause 5-7 feet of flooding at this house, again causing a serious threat of loss of life.

Waterman Brook and the draw both cross Highway 112 before entering the

Ferman Brook - 3400 Downstream of Lower Mountain Lake Dam

D-22

===== DATA FOR THE COMBINED SYSTEM =====

DEPTH ft.	ELEV ft.	AREA ft↑2	WPER ft.	HYD-R ft.	AR2/3	Q cfs
0.00	0.0	0.0	0.0	0.0	0.0	0.0
0.50	0.5	5.3	11.4	0.5	3.1	26.1
1.00	1.0	11.0	12.8	0.9	9.9	82.7
1.50	1.5	17.3	14.2	1.2	19.6	163.3
2.00	2.0	24.0	15.7	1.5	31.9	265.8
2.50	2.5	31.3	17.1	1.8	46.8	389.5
3.00	3.0	39.0	18.5	2.1	64.2	534.4
3.50	3.5	47.3	19.9	2.4	84.1	700.5
4.00	4.0	56.0	21.3	2.6	106.6	888.2
4.50	4.5	67.5	31.4	2.2	112.5	1141.9
5.00	5.0	84.0	41.4	2.0	134.6	1434.2
5.50	5.5	105.5	51.5	2.1	170.3	1773.0
6.00	6.0	132.0	61.5	2.1	219.6	2164.4
6.50	6.5	163.5	71.6	2.3	283.6	2614.4
7.00	7.0	200.0	81.6	2.5	363.5	3128.1
7.50	7.5	241.5	91.7	2.6	460.7	3710.4
8.00	8.0	288.0	101.7	2.8	576.4	4366.2
8.50	8.5	339.5	111.8	3.0	712.1	5099.8
9.00	9.0	396.0	121.8	3.3	869.0	5915.8
9.50	9.5	457.5	131.9	3.5	1048.5	6818.2
10.00	10.0	524.0	141.9	3.7	1251.8	7811.2
10.50	10.5	595.5	152.0	3.9	1480.2	8898.7
11.00	11.0	672.0	162.0	4.1	1734.8	10084.8
11.50	11.5	753.5	172.1	4.4	2016.9	11373.0
12.00	12.0	840.0	182.1	4.6	2327.6	12767.3
12.50	12.5	931.5	192.2	4.8	2668.1	14271.2
13.00	13.0	1028.0	202.2	5.1	3039.4	15888.4
13.50	13.5	1129.5	212.3	5.3	3442.7	17622.4
14.00	14.0	1236.0	222.3	5.6	3879.1	19476.6

OLSEN DAM

TCG
6/16/80

Wild Ammonoosuc River. Waterman Brook goes through a 5 ft. by 10 ft. bridge opening, while the draw would simply flow over the roadway embankment. Highway 112 would be overtopped by Waterman Brook and possibly be damaged by the pre-failure flow of 1640 cfs. The 17,600 cfs flow after failure would cause extensive damage to the highway in this area.

The Wild Ammonoosuc River is a considerably larger stream than Waterman Brook, and dam failure would begin to attenuate in the river. The river is paralleled by Highway 112 for the 1.5 miles from Waterman Brook to U.S. Highway 302. The only structure in this reach is a single house, which is well above the river and out of flooding danger. Less than 0.5 mile downstream of U.S. Highway 302, the Wild Ammonoosuc joins Ammonoosuc River, an even larger stream in which dam failure flows would rapidly attenuate.

The chart on the following page summarizes the downstream impacts of the failure of Olsen Dam.

Location & Number (see map)	Distance Downstream of Dam (ft.)	# of Structures	Level above Stream (ft.)	Flow & Stage Before Failure	Flow & Stage After Failure	Comments
just below dam	-	-	-	1640 cfs	13,375 cfs	Outflow directly to Lower Mountain Lake.
1. Lower Mountain Lake Dam	2500	-	-	1640 cfs 777.8 ft msl	1765 cfs+ 778 ft msl+	Dam overtopped, probable failure.
just below Lower Mountain Lake Dam	2500	1 pump station	6	1640 cfs 4 ft.	17,600 cfs 15 ft.	Failure of Lower Mountain Lake Dam causes large increase in flow downstream.
Goose Pond Road	3700	bridge	8'x 6' culvert	1640 cfs	17,600 cfs	Roadway embankment overtopped before failure. Certainly damaged or destroyed after failure.
2. House 200 ft. upstream of Highway 112	5800	1 house	5	1640 cfs 5 ft.	17,600 cfs 14 ft.	8-9 ft. of flooding at the house - serious threat of loss of life.
2. Draw from Waterman Brook to Highway 112	6000	1 house	2	trace	7-9 ft.	5-7 ft. of flooding at the house - serious threat of loss of life.
3. Highway 112	6000	1 bridge	5'x 10'	-	-	Bridge overtopped and possibly damaged before failure. Serious damage t bridge and roadway embankment after failure.
3. Juncture with Wild Ammonoosuc River	6100	-	-	1640 cfs	17,600 cfs	Larger river would begin t attenuate flood wave. No further serious damage anticipated.

OLSEN DAM

TCG
6/16/80

Test Flood Analysis

Size classification: SMALL (Storage between 50 and 1000 ac-ft.; height less than 40 ft.)

Hazard classification: HIGH. The failure of Olsen Dam would cause the overtopping and probable failure of Lower Mountain Lake Dam. Assuming the failure of Lower Mountain Lake Dam, downstream impacts would include the destruction of a water supply pump station, the destruction of 2 houses with a possibility of loss of life, and the destruction of portions of New Hampshire Highway 112.

According to the Corps' "Recommended Guidelines", the hazard classification and dam size indicate a test flood between ½ of the probable maximum flood (PMF) and the PMF. Since the hazard classification is on the low side of HIGH, we will use the ½ PMF.

According to the Corps' "Maximum Probable Flood Peak Flow Rates" curve for New England, the peak PMF inflow for a 3.35 sq. mile drainage basin with mountainous terrain would be 2350 csm.

Peak inflow = (½) 2350 csm (3.35 sq. miles) = 3935 cfs.

The attenuation of the test flood due to storage in the reservoir is calculated on the next page.

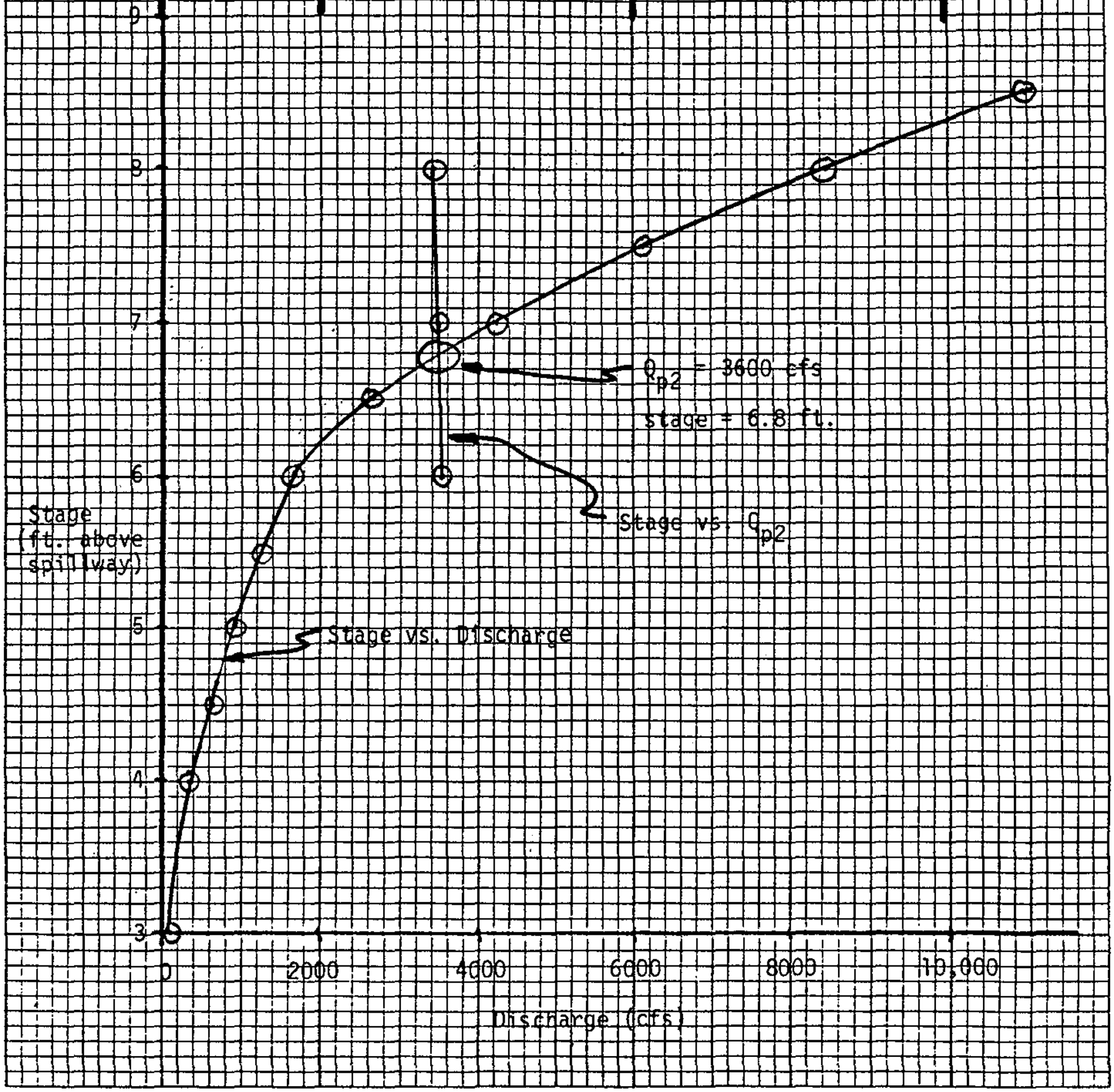
The peak test flood outflow is 3600 cfs, with a peak stage of 782.4 ft. msl, 6.8 feet above the principal spillway crest, 3.2 feet above the emergency spillway crest, and 0.8 feet above the dam crest.

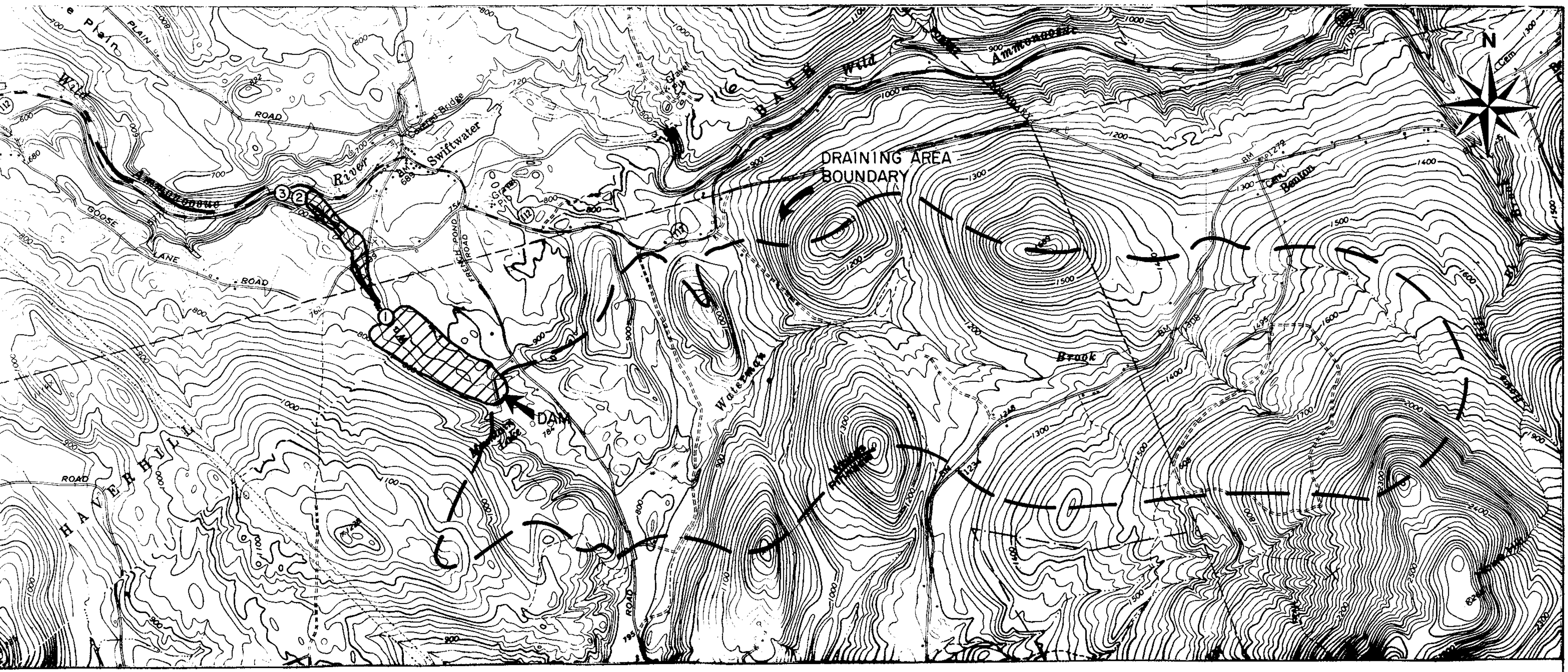
The peak test flood outflow is $\frac{3600}{1640}$ = 220% of the spillway capacity with the water surface at the dam crest. Approximately 1430 cfs of the test flood outflow would flow over the dam crest.

Attenuated Peak Test Flood Outflow at Olsen Dam TCG 6/16/80

$$Q_{p2} = Q_{p1}\left(1-\frac{STOR}{9.5''}\right) = 3935\left(1-\frac{STOR}{9.5''}\right)$$

Stage (ft. above spillway)	Surcharge Storage (ac-ft.)	STOR (Sur. Stor. x .0056) (inches of runoff)	Q_{p2} (cfs)
6	162	0.91	3560
7	189	1.06	3500
8	216	1.21	3430





LOCATION 1 = Lower Mountain Lake DAM and water supply pump station.
LOCATION 2 = House and draw leading to second house
LOCATION 3 = Highway 112 crossing; juncture with the Wild Ammonoosue River
= Approximate areal extent of downstream flood hazard

- SCALE -

0 1000 2000 4000 (FEET)

FROM: USGS EAST HAVEHILL AND LISBON, NEW HAMPSHIRE QUADRANGLE MAPS

GOLDBERG ZOINO & ASSOCIATES, INC. GEOTECHNICAL-GEOHYDROLOGICAL CONSULTANTS NEWTON UPPER FALLS, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND DOWNSTREAM HAZARD MAP

FILE No.2605

OLSEN DAM — HAVERHILL, NEW HAMPSHIRE

SCALE AS NOTED

DATE AUGUST 1980

APPENDIX E

INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS